THE

AMERICAN NATURALIST

VOL. XXXII. *May, 1898.* No. 377.

THE ORIGIN OF THE MAMMALIA.[1]

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THE most important problems in vertebrate morphology at the present time are the connections which once existed between the great vertebrate classes. As regards the three lower classes, the present state of opinion is as follows: The Amphibia are derived by Pollard, Cope, Dollo, and Baur from the ancient crossopterygian fishes, an order represented by the modern Polypterus and Calamoicthys, the Dipnoi being regarded as a parallel rather than an ancestral line. The Reptilia, as represented by their most primitive order with solid-roofed skulls (Cotylosauria, Cope, or Pareiasauria, Seeley), are believed to have sprung from that type of stegocephalian Amphibia which possessed rachitomous vertebræ, or with centra and intercentra. This division between reptiles and amphibians must have occurred as far back as the base of the Permian, or even in the Upper Carboniferous, because in the Middle Permian we find several orders of highly specialized reptiles, namely, the Cotylosauria, Cope, Proganosauria, Baur, Dicynodontia, Owen, and Theriodontia, Owen, highly specialized in the so-called Gom-

[1] A paper presented in part before the British Association for the Advancement of Science at Toronto, and in full before the New York Academy of Sciences. Jan. 10, 1898.

phodontia and Cynodontia. Allied to the Proganosauria, moreover, are such widely diverse types as Palæohatteria, Protorosaurus, and Kadaliosaurus.

The origin of the Mammalia is enshrouded in still more doubt. Without the aid of paleontology, Huxley, in 1880, related his Hypotheria, or oldest types of mammals, to the ancient Amphibia.

In the writer's full notes upon Professor Huxley's lectures delivered in his course of 1879–80 occurs the following sentence: "When we find a form that bridges over this gap (that is, between lower vertebrates and mammals) it will in all probability have *a double condyle caused by a reduction of the basioccipital and increase of the exoccipital parts.* The quadrate will have begun to diminish and the squamosal to enlarge, coming into relation with the angular and surangular. That this promammal will be discovered when the immense number of reptilian remains from the older rocks are studied I myself have little doubt." This the writer regards as a more successful forecast than that published by Huxley a year later. At this time he was evidently thinking over his now famous paper of Dec. 14, 1880,[1] in which occurs the following paragraph: "Our existing classification has no place for this submammalian stage of evolution (already indicated by Haeckel under the name of *Promammale*). It would be separated from the Sauropsida by its two condyles, and by the retention of the left as the principal aortic arch; while it would probably be no less differentiate from the Amphibia by the presence of the amnion and the absence of branchiæ in any period of life. I propose to term the representatives of this stage Hypotheria; and I do not doubt that when we have a fuller knowledge of the terrestrial vertebrata of the later Palæozoic epochs, forms belonging to this stage will be found among them. . . . Thus I regard the amphibian type as a representative of the next lower stage of vertebrate evolution. From the Hypotheria, as schematically shown on page 659, in which the mandible articulates with the quadrate, were derived the Prototheria, in which the large free malleus takes the place of the quadrate; from this type sprang the Metatheria, and from these, in turn, the Eutheria."

It is clearly implied by Huxley that the promammal had the paired occipital condyle of the ancient Amphibia, — an assumption of great morphological importance, and differing from that expressed in his earlier lecture quoted above. He also, in his preconception of the homology of the quadrate with the malleus, lightly passes over the difficulty of freeing the quadrate from the squamosal, to which it is closely joined in all the Amphibia. In brief, this brilliant paper lacks the author's usual unsparing logic.

[1] On the Application of the Laws of Evolution to the Arrangement of the Vertebrata, and More Particularly of the Mammalia. *Proc. Zool. Soc. of London*, Dec. 4, 1880, p. 659.

This amphibian hypothesis has recently been supported by Hubrecht (1896), who upon embryological grounds specifically connects the mammals with the stegocephalian Amphibia.

He concludes his very interesting and suggestive lecture, "The Descent of the Primates," by the passage (p. 31): "In fact, there is really not one potent reason which would prevent us from deriving arrangements, as we find them in the placental mammals, directly from viviparous amphibian ancestors." Again (p. 37): "My own choice is fixed upon the latter hypothesis, because in the Amphibia, from which I suppose the earliest placental mammals to have been derived, we find arrangements that appear to explain the origin of the amnion in the way here advocated."

There are numerous structures in the soft anatomy, not only of the monotremes, but of the placentals, which recall the amphibian type. Beddard has demonstrated the existence of an anterior abdominal vein in the monotremes. Howes [1] has compared the amphibian epiglottis with that of the mammals. Hubrecht [2] directs our attention to Klaatsch's [3] comparison of the close relations existing between the intestinal arteries of mammals and the most primitive arrangements of these vessels among amphibians. Elsewhere Hubrecht (*op. cit.*) declares that the mammals must be connected with very primitive forms that have already diverged from the common stem of the Chordata below the point of divergence of the amphibians now living, or, as we should add, from the stegocephalian type. Maurer [4] concludes that in the epidermal sense organs and hairs the mammals diverge considerably from the Sauropsida.

Cope, on the other hand, in 1884, derived the mammals from carnivorous reptiles of the group Theromorpha and order Pelycosauria.

Professor Cope, upon discovering the foot of the pelycosaurs with its supposed posterior spur, compared it with that of the monotremes, and hastened to the conclusion that these animals stood very near the ancestors of the mammals. He was long on record as deriving the Reptilia from the Batrachia with *embolomerous* (rather than rachitomous) vertebræ, and from the pelycosaurian Reptilia, the Mammalia. In his *Primary Factors of Organic Evolution*, 1896, he writes: "I have traced the origin of the mammal to theromorous reptiles of the Permian." In this latest expression of his opinion upon the subject, however, he divided the Theromora into Theriodontia, Pelycosauria, and Anomodontia, and upon the opposite page

[1] G. Howes, *Proc. Zool. Soc. of London*, 1887, p. 50.

[2] *Op. cit.*, p. 38.

[3] H. Klaatsch, Zur Morphologie der Mesenterialbildungen am Darmcanal der Wirbelthiere. *Morph. Jahrb.*, Bd. xviii, Sec. 643.

[4] F. Maurer, *Morph. Jahrb.*, Bd. xviii.

gave a phylogeny of the Mammalia, which showed that his latest views coincided with those here expressed, and that he recognized the force of Baur's criticisms cited below.

Baur in 1886 dissented from Cope's specific conclusion, but committed himself to the theory of indirect reptilian origin of the mammals, by substituting the term Sauro-mammalia for Huxley's Hypotheria, and placing the Theromorpha as parallel, rather than ancestral, to the Mammalia.

Professor Baur's paper of 1886, "Ueber die Kanäle im Humerus der Amnioten," demonstrated that the known Theromorpha are much too specialized to be regarded as ancestors of the mammals, as Professor Cope supposed. To the hypothetical group which gave origin to both Theromorpha and Mammalia Baur gave the name Sauro-mammalia, expressing a similar view in his essay of 1887, "Ueber die Abstammung der Amnioten Wirbelthiere," *Gesell. f. Morph. u. Physiologie*, München, 1887. In his recent paper (1897), showing that the pelycosaurs are highly specialized reptiles, Baur, however, gave his strong adherence to the theriodont ancestry as follows: "We are fully convinced that among these South African forms, one of which (Tritylodon) was for a long time considered a mammal, we have those reptiles which might be considered as ancestral to the mammals, or at least closely related to their ancestors. Further finds and careful critical observations have to decide this." [1]

The writer, in his university lectures of 1896, advocated the same view, having been strongly impressed during the previous year with Professor Seeley's descriptions of Cynognathus and the Gomphodontia.

Osborn,[2] in 1888, selected the Upper Triassic mammals Dromatherium and Microconodon as types of the mammalian order Protodonta, with teeth transitional between those of reptiles and mammals. Subsequently, in 1893,[3] he accepted Baur's view, deriving both the Promammalia and Theromorpha from Permian Sauro-mammalia.

In fact, Cope long diverted our attention from these South African theromorphs, which as originally perceived by Owen in 1876 are full of mammalian analogies, to the pelycosaurs

[1] On the Morphology of the Skull of the Pelycosauria, and the Origin of the Mammals. By G. Baur and E. C. Case. Zoological Club, University of Chicago, February 10; also *Science*, April 9, 1897, pp. 592-594.

[2] On the Structure and Classification of the Mesozoic Mammalia. *Journ. Acad. Nat. Sci.*, p. 251, Philadelphia, 1888.

[3] Rise of the Mammalia in North America. *Proc. Am. Assoc. Adv. Sci.*, p. 188, 1893.

which prove to be unrelated to the theromorphs and still less to the mammals.

The most important series of explorations in the Karoo Beds of South Africa, directed by Professor Seeley, thus turn our thoughts upon the origin of the mammals into the old channel considered by Owen, in spite of his indefinite views of evolution. The animals first described by him as Cynodontia and later as Theriodontia in 1876, both terms being given in full recognition of the resemblances which these animals presented to the Mammalia in their teeth, are, thanks to these explorations, very much more fully known. Seeley's successive memoirs

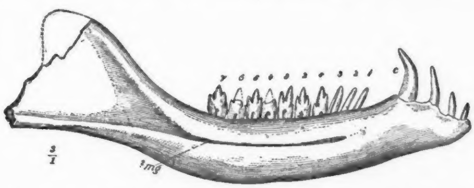

FIG. 1. — Jaw of *Dromatherium sylvestre*, a protodont from the Upper Triassic of North Carolina.

detail many of their numerous points of likeness to the recent and extinct Mammalia. These memoirs may therefore be reviewed in connection with previous speculations as to the ancestry of the mammals. We may critically consider the question of resemblances, in order to determine how far we are justified in supporting the hypothesis that the mammals sprang from the theriodont reptiles.

Seeley (1896, pp. 183, 184) has recently referred the species *Labyrinthodon rütimeyeri* of Wiedersheim to a new genus, Aristodesmus. After pointing out the numerous resemblances of this form to the monotremes, he closes as follows :

In conclusion, the author argues that the points of structure are so few in which monotreme mammals make a closer approximation to the higher mammals than is seen in this fossil and other Anomodontia that the monotreme resemblances to fossil reptiles become increased in importance. He believes that a group Theropsida might be made to include Monotremata and Anomodontia, the principal differences (other than those of the skull) being that monotremes preserve the marsupial bones, the atlas vertebra, and certain cranial sutures. Ornithorhynchus shows prefrontal and postfrontal bones, and has the malar arch formed as in anomodonts.

Aristodesmus, which suggests this link, is at present placed in the Procolophonia, a group separated from its recent association with Pareiasaurus, and restored to its original independence because it has two occipital condyles, with the occipital plate vertical and without lateral vacuities, and has the shoulder girdle distinct from Pareiasauria in the separate precoracoid extending in advance of the scapula.

A similar view is that of Mivart, who removes the monotremes so far from the marsupials and placentals as to conclude that they arose from sauropsidan ancestors, while the higher mammals, marsupials and placentals sprang independently from Amphibia-like stem forms.[1]

I. CHARACTERS OF THE PROMAMMAL.

It is obvious that to establish a point of connection we should first take characters furnished by the most ancient members of the class of mammals and picture the mammalian prototype or promammal.

As regards the teeth, I made such an attempt in 1893 (*Rise of the Mammalia*) in the following terms:

The Permian Sauro-mammalia (Baur) with a multiple succession of simple conical teeth divided into: (1) Theromorpha, which lost the succession and in some lines acquired a heterodont dentition and triconid single-fanged molars; (2) Promammalia. The hypothetical Lower Triassic Promammalia retained a double succession of the teeth; they became heterodont, with incipient triconid double-fanged molars, the dental formula approximating 4, 1, 4–5, 8. They gave rise to three groups: (*a*) The Prototheria, which passed rapidly through the tritubercular into the multitubercular molars in the line of multituberculates, and more slowly into trituberculy, and its later stages in the line of monotremes. (*b*) They gave off the Metatheria, or marsupials, and finally (*c*) the Eutheria, or placentals.

In the same address I took very positively the position that the simple reptilian cone is the ancestor of the multitubercular as well as of the tritubercular dental types, and that the multituberculate teeth observed in the Triassic were not primitive, but had precociously passed through a tritubercular stage. I derived the characters of the promammal from a study of all the known Jurassic Mammalia. The inference as to the multiple succession of the teeth I subsequently based upon the recent embryological demonstration that all living mammals are diphyodont and sprang from polyphyodont ancestors (a principle that

[1] *Proc. Roy. Soc.*, vol. xliii, p. 372.

has recently been thrown in doubt by Woodward). The hypothesis as to the derivation of the multitubercular from the tritubercular teeth was based upon the fact that certain rodents, although unquestionably of trituberculate origin, present typical multituberculate teeth. Summing up as follows: The *Lower Triassic ancestors of monotremes, marsupials, and placentals possessed teeth differentiating into different kinds* (*incipiently heterodont*), *molars with three cones* (*triconodont*) *and dividing fangs* (*Proto-*

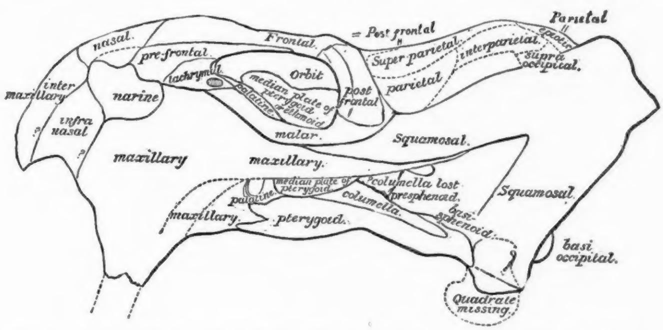

FIG. 2. — Lateral view of the skull of Dicynodon, showing Seeley's interpretation of the cranial elements. (After Seeley.)

donta), *giving rise both to the multituberculate and trituberculate types, with the dental formula: incisors, 4; canines, 1; premolars, 4 or 5; molars, 8.*

These assumptions are in a measure confirmed by Professor Seeley's discoveries, but the Theromora in the large sense reassume a position *ancestral* to rather than *parallel* with the mammals. Before bringing out all the grounds for this statement let us review the osteological and dental promammal characters side by side with theriodont characters.

II. History of Discovery.

Professor Owen defined the Theriodontia in 1876 as follows: "Dentition of a carnivorous type; incisors defined by position, and divided from molars by a large laniariform canine on each side of both upper and lower jaws, the lower canine crossing in front of the upper; no

ectopterygoids; humerus with an entepicondylar foramen; digital formula of fore foot, 2, 3, 3, 3, 3 phalanges."

No definition could be clearer, and upon the following page Owen suggests the hypothesis that these forms may have given rise to the mammals "by secondary law, the mode of operation of which we have still to learn."[1]

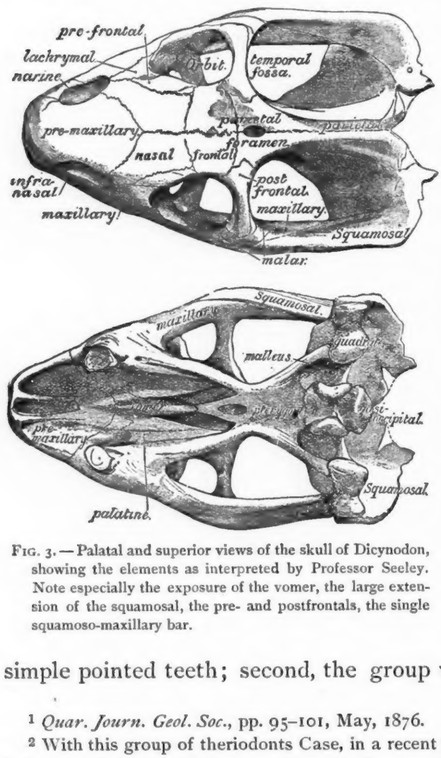

FIG. 3. — Palatal and superior views of the skull of Dicynodon, showing the elements as interpreted by Professor Seeley. Note especially the exposure of the vomer, the large extension of the squamosal, the pre- and postfrontals, the single squamoso-maxillary bar.

This definition was subsequently enlarged by Owen himself, and has been extended by Seeley. So that now this order includes forms having great diversity in their dentition, but apparently related in their osteological characters.

Thus, says Seeley (1895, 1, p. 997), the Theriodontia as originally defined included: first, the group of animals with skulls formed on the type of Lycosaurus[2] with simple pointed teeth; second, the group with skulls formed on

[1] *Quar. Journ. Geol. Soc.*, pp. 95–101, May, 1876.

[2] With this group of theriodonts Case, in a recent paper (*American Naturalist*, February, 1898, p. 73), also associates the Lycosauria; Lycosaurus being a type which furnishes a transition from the supposed fusion of the upper and lower temporal arches into the single zygomatic arch of the Mammalia, as shown in the following synopsis:

Cynodontia: Quadrate covered by supporting bones. Teeth showing small lateral tubercles. Arches more closely approximated than in Procolophonia.

Lycosauria: Quadrate small, covered by supporting bones. Skull depressed. Teeth with well-developed tubercles. Arches united.

Gomphodontia: Quadrate very small and inclosed in squamosal. Teeth tuberculate. Palate mammalian. Arches united.

the type of Thrinaxodon, which lacked the incisor teeth. One of the principal features in common is the structure of the palate, resembling that of the Mammalia in the opening of the palato-nares between the molars.

Seeley distinguishes the theriodonts from the dicynodonts by the following characters: The postorbital arch is similar, but in the theriodonts the malar bone has a greater backward extension, and in the dicynodonts the squamosal has a greater downward development, the latter difference being due to *the degeneration of the quadrate in the theriodonts.* Dicynodon, moreover, has a tripartite condyle, as in the Chelonia (composed equally of basi- and exoccipitals); while the theriodonts have paired condyles, as in the Mammalia (1895, 5, p. 129), with a depressed basioccipital portion. Both types show mammalian analogies in the palate, as well as a fixed and reduced quadrate.

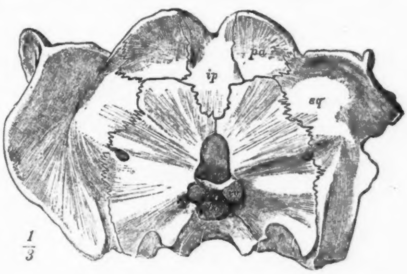

FIG. 4. — Posterior view of the occiput of *Ptychosiagum declive.* A dicynodont, showing the tripartite structure of the occipital condyle, the large interparietal, the extension of the squamosal upon the occiput. The bones lettered *pa* correspond in position with the epiotics in the labyrinthodont amphibia. (After Lydekker.)

In the palate of Dicynodon the palatine bones are separated by the vomers in the median line. The occiput is broad and flat, bounded by the parietals and interparietals above, there being a deep notch in the median line. The bones doubtfully described by Owen as paroccipitals ("opisthotics" of Huxley) are fused with the exoccipitals, as observed by Huxley in Ptychognathus and by Seeley in other forms. Laterally, the occiput is formed by the *squamosals,* elements which are very extensively developed in Dicynodon, largely covering the quadrate and descending to form *nearly half of the glenoid facet for the lower jaw,* a very important character. In this respect this genus is more mammalian than the theriodonts, in which the squamosal does not form part of the glenoid facet.

In the palate, however, the theriodonts are more mammalian, since the palatine bones meet in the median line defining the posterior nares. In both types the orbits are closed posteriorly by the postorbitals and postfrontals. The zygomatic arch in both has a large malar as well as a large squamosal.

The shoulder girdle in both presents a metacoracoid and epicoracoid, the latter perforated by a foramen, as well as a clavicle and interclavicle, thus strongly resembling the monotreme type. Dicynodon, like Gomphognathus among the theriodonts, has a decidedly promammalian type of humerus, with a prominent deltopectoral crest, an entepicondylar foramen, and prominent ent- and ectepicondyles. The pectoral arch exhibits a narrow scapula and large epi- and metacoracoids entering also into the glenoid fossa. The pelvis shows an ilium expanded above, a ventrally united ischium, and pubis with a rudimentary obturator foramen, all three bones entering equally into the acetabulum.

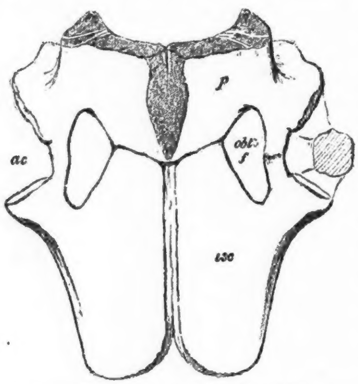

FIG. 5.—Ventral aspect of the pelvis of Cynognathus, showing the relations of the pubis, the ischium, obturator foramen. (About ½ natural size. After Seeley.)

It is clear that the dicynodonts and theriodonts hail from a common stock, the superorder Thermora of Cope, the former showing the greater specialization and aberrancy. To this superorder the term Anomodontia is given by most English authors, but it is inapplicable, because Owen invariably defined the Anomodontia in such a manner as to embrace only the dicynodonts. The first comprehensive term was that given by Cope.

III. ORDER THERIODONTIA, OWEN.

It is a most striking fact that the theriodonts proper appear to include two suborders, which, so far as we know, are as

closely united in skeletal characters as they are dissimilar in dental characters. These are:

1. Suborder *Cynodontia:* Carnivorous animals, with cutting triconodont molars.

2. Suborder *Gomphodontia:* Herbivorous animals, with triturating, low-crowned, tritubercular and multitubercular teeth.

The teeth of these animals are even more widely differentiated than those of the Mesonychidæ and Arctocyonidæ among the Creodonta. Compared with living types, they are as wide apart as those of Thylacinus and Mus. Upon the "tritubercular theory" the dentition of the cynodonts is the most primitive. Upon the "multitubercular theory" it would be considered the most specialized.

The skeleton of the Cynodontia is by far the best known.

1. *The Cynodontia.*

The most perfectly known type is Cynognathus. The skull of Cynognathus is over a foot (15¾ inches) long. This animal was a large and powerful carnivore, the tooth structure

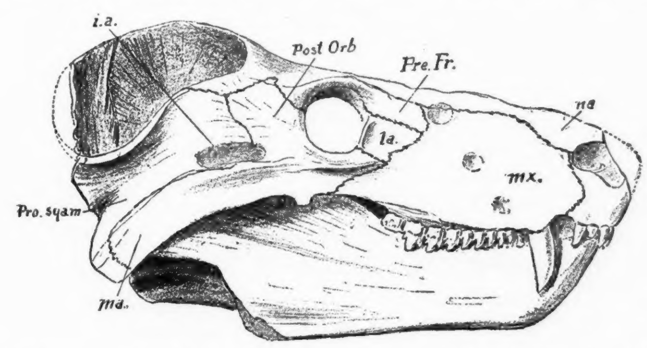

FIG. 6.—Lateral view of skull of *Cynognathus crateronotus*, showing the dentary element in the mandible; the incipient angle; the compound nature of the zygomatic arch, with an open infratemporal fossa, *ia*. (⅜ natural size. After Seeley.)

superficially resembling that of Thylacinus or Dissacus. The skull widens posteriorly, but in lateral view it is strikingly mammalian and cynoid (1895, 5, p. 61). The anterior nares are divided, terminal and lateral, the snout as seen from above

being bulbous, as in Tritylodon, covered by long nasals with a short free portion. Large lachrymals, and, conforming with the carnivorous habit and strong temporal muscles, there is a high sagittal crest, deep temporal fossæ and a strong, deep zygomatic arch, powerful chin and coronoid process (formed from the dentary). The serrated teeth agree in number with Osborn's promammalian formula, consisting of four incisors, powerful canines, five pointed and basal cusped premolars, and four triconid molars. As in the Protodonta, the molar fangs are slightly grooved, indicating a division into two roots.

There are also incipient traces of a cingulum (1895, 5, Fig. 2) and some evidence that there was a succession of the teeth

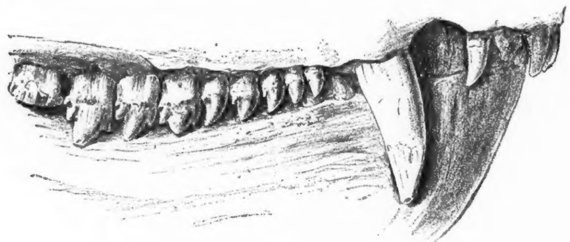

FIG. 7. — Lateral view of the teeth of *Cynognathus crateronotus*, showing the five simple premolars and triconodont molars with grooved fangs. (½ natural size. After Seeley.)

(1895, 5, p. 62). All these are promammalian characters. A close approximation to this type is in the marsupial Triconodon of the Upper Jurassic. Professor Seeley has pointed out (1895, 5, p. 90), also, that there exists a still closer resemblance between this type and Microconodon.

A perforation behind the orbits, which Cope and Baur, and very recently Case,[1] have considered as possibly representing the infratemporal fossa, is regarded by Seeley as a vacuity. Upon page 74 (1895, 5) Seeley also compares this vacuity with the infratemporal fossa. According to this interpretation, the mammalian zygoma was originally a compound structure, composed of the squamosal + prosquamosal above and the quadratojugal below. A palate, formed apparently by hori-

[1] *American Naturalist*, February, 1898, p. 73. This paper contains a valuable critique of the same subject from the standpoint of the temporal arches.

zontal palatine and maxillary plates, and two (exoccipital) condyles complete the mammalian facies.

The origin of the paired occipital condyles of the Mammalia is a matter of great importance. We observe a tripartite condyle in Dicynodon and in the Chelonia, into which the basi- and exoccipitals enter about equally; certain types of Lacertilia, such as Uroplates and Gecko (*fide* Cope), also evidently acquired their bipartite condyles secondarily by the recession of the median basioccipital element. It would appear, therefore, that the theriodonts, in which this median basioccipital element is still quite prominent, also acquired the paired exoccipital condyle in the same manner, *i.e.*, secondarily, or from the tripartite type, such as that seen in Dicynodon. We would thus have the explanation of the development of this paired structure from a reptilian tripartite condyle, as in Huxley's original conjecture, rather than directly from an amphibian paired condyle, for in the Amphibia the paired condition of the condyles arises in an extremely early period, rather than by a secondary recession of the basioccipital element.

FIG. 8.—External and anterior views of the left shoulder girdle, supposed to belong to Cynognathus, showing the scapula, parts of coracoid, precoracoid, and precoracoid foramen. (¼ natural size. After Seeley.)

Of the transitional characters of Cynognathus, the reduced and overlapped quadrate is what we should expect to find in a promammal upon the Albrecht-Cope-Baur theory that the quadrate in the mammalia is fused with the squamosal. Among the reptilian characters are the separate prefrontal and postfrontal elements (the postorbitals being united with the malars), as well as the constitution of the lower jaw out of distinct elements (angular, articular, dentary, splenial), which by reduction and

fusion with adjacent elements might, however, pass into a mammalian prototype.

Some of the peculiar adaptive features of this type are the very elevated position of the squamosals (as in certain plesiosaurs); the paroccipitals or opisthotics exhibit large posterior vacuities, as in Dicynodon, and are united with exoccipitals; basioccipitals narrow; the epiotics are said to be separate (1895, 5, p. 77); the alisphenoids and orbitosphenoids are defined; laterally we observe descending plates of the pterygoids or "transverse-palatine" bones.

The angular region of the jaw of Cynognathus is unfortunately wanting, but it is improbable that the placental type of angle was present. Seeley points out (1895, 5, p. 90) that the rudimentary mammalian angle may consist of the posterior border of the dentary, and concurs with Osborn [1] *that the angle arose anteriorly on the lower border of the jaw* (as perhaps in Microconodon, Amphitherium, and Peramus) *and was subsequently shifted backwards.*

Remains of the shoulder girdle show that a coracoid (metacoracoid) and epicoracoid with foramen were present (as in Dicynodon), and more striking still as a point of resemblance to the monotremes is the spine and acromion of the scapula, consisting of "the anterior edge of the scapula developed upward" (1895, 5, p. 92).

Of the vertebræ preserved (1895, p. 97) there are six cervicals, eighteen dorsals, five lumbars; the first of these has the spine and odontoid process characteristic of the mammalian axis, the atlas being probably lost. The formula is estimated as: C.–6, D.–18, L.–5, S.–4. The writer has estimated the dorsolumbar formula of the primitive mammal at D. = 15, L. = 5, or D.L. = 20. The cervicals exhibit large intercentra (structures seen in a vestigial form in embryonic Insectivora and other mammals), to which, as well as to the centra, the heads of ribs are partly attached, certainly in the case of two vertebræ (*op. cit.*, p. 99), while the rib tubercles unite with the pleurapophyses of the vertebra posterior in true mammalian fashion. In the *dorsal* region (*op. cit.*, p. 104) no intercentra are described;

[1] See *Mesozoic Mammalia*, p. 223.

the heads of the ribs are intercentral or articulate between the centra and the tubercles to the succeeding vertebræ (as in mammals). Certain structures in the dorsal (D.–12) vertebræ resemble a zygophen-zygantrum articulation, compensating perhaps for the imperfectly developed zygapophyses. In the poste-

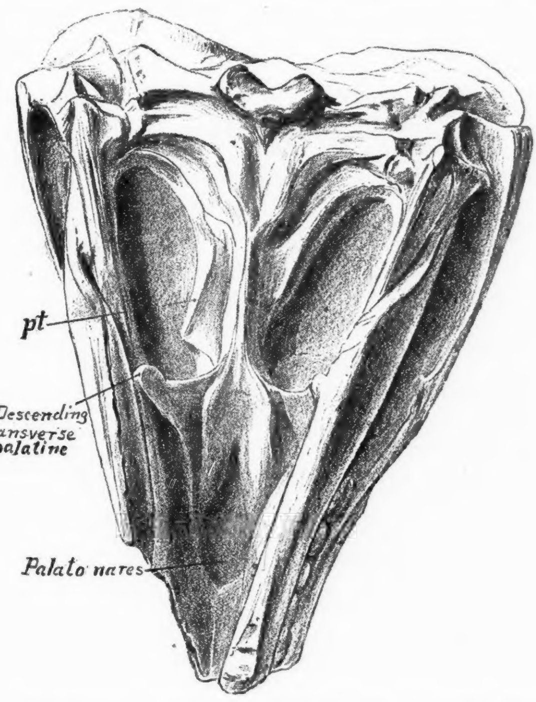

FIG. 9. — Palate of *Cynognathus platyceps*, showing the composite structure of the lower jaw, the descending transverse plates of the palatines, occipital condyle with a large basioccipital element. ($\frac{2}{3}$ natural size. After Seeley.)

rior dorsals the ribs are suturally anchylosed to the vertebræ and extend outwards into overlapping plates. Only two of the supposed sacrals are anchylosed.

The pelvis is remarkably mammalian in the structure of its ventrally united ischium and pubis, with obturator foramen (rudimentary in Dicynodon), the three bones forming the acetabulum. But it differs from the early mammalian type in the widely

expanded supra-iliac border. There is some evidence of the existence of marsupial bones, as in the monotremes and marsupials (*op. cit.*, p. 117). The femur, so far as preserved, is less mammalian in type; the trochanter minor is very prominent and extends far down the shaft.

All the above characters are observed in the single skeleton of *C. crateronotus*. In skulls of *C. berryi* are found two condyles formed from exoccipitals only (*op. cit.*, p. 129), separate pre- and postfrontals, greater coalescence of the jaw elements, an inferior dental formula estimated at:

I, 3.–C, 1.–P, 4.–M, 5.

Another species, *C. platyceps*, an animal about the size of a wolf, lacks the supposed infratemporal opening (Fig. 10) above the malar arch. The quadrate is hardly distinguishable from the squamosal. The lower jaw exhibits evidence of a splenial (*op. cit.*, p. 140) in process of degeneration. A third species,

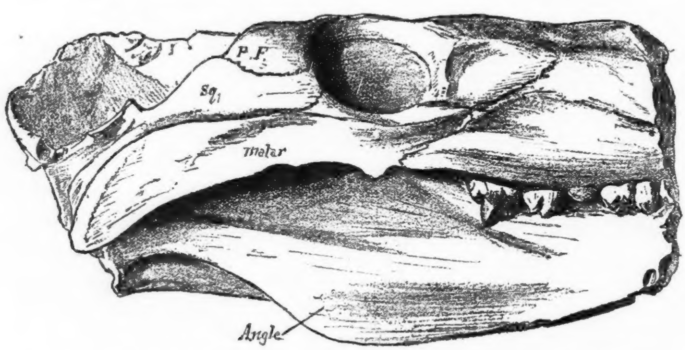

FIG. 10. — Lateral view of skull of *Cynognathus platyceps*, showing the union of the prosquamosal and malar elements, closing in the infratemporal fossa. Angle developed as in Microconodon. (After Seeley.)

probably generically distinct, is *C. leptorhinus*, with a median nasofrontal pit upon top of the face and two specialized canines.

A carpus doubtfully referred to Cynognathus (1895, 5, p. 145) exhibits elements which Seeley interprets as a united scapholunar, cuneiform, pisiform, and portions of the centrale.

2. *The Gomphodontia.*

All the remains of this group have been found in the upper Permian Beds of Ailwell North and Lady Frere, contemporary with the specialized theriodonts. The geological position of Tritylodon is not certainly known, but the other gomphodont genera, Gomphognathus, Microgomphodon, Trirachodon, and Diademodon, are certainly located in these upper Karoo Beds, and are below the Stormberg Beds, which are considered Triassic. Seeley (1895, 4) confidently places these animals in the order Theriodontia (contrasting them with the carnivorous Cynodontia) as typical herbivorous forms with molar teeth flattened and expanded transversely and more or less tuberculate crowns. The cranial and skeletal characters, so far as they are

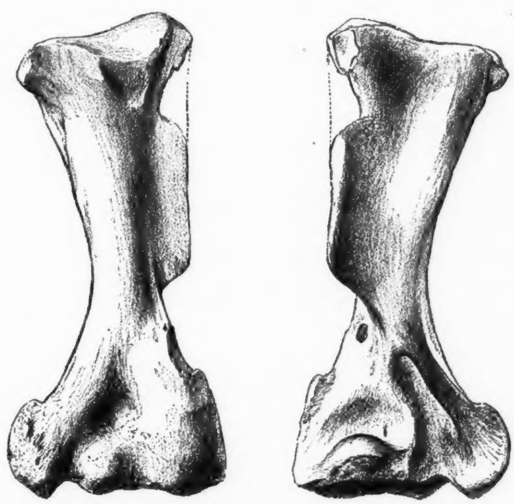

FIG. 11. — Anterior and posterior views of a right humerus referred to Gomphognathus, showing powerful deltoid crest, entepicondyle, entepicondylar foramen; separate articular facets for radius and ulna. ($\frac{1}{2}$ natural size. After Seeley.)

known, support Seeley's conclusion, and the wide diversity in the structure of the teeth does not alone constitute a sufficient ground for the separation of these herbivorous forms from the carnivorous Theriodontia. If Tritylodon belongs to this group,

as seems to be very probable if not absolutely demonstrated, it is certainly the most highly specialized, in the possession of strongly developed intermediate tubercles on the upper molars, which are only feebly developed in Diademodon.

The skull is partly known in the genera Gomphognathus, Microgomphodon, and Trirachodon. As in the Cynodontia, the temporal fossæ are separated by a more or less distinct sagittal crest, less prominent than in the Cynodontia because of the reduction of the temporal muscles. As in the Cynodontia, the zygomatic arch is formed by the malar and squamosal bones, and the orbit is separated from the temporal fossa by the post-orbital (postfrontal, Seeley) bone. There are two well-defined occipital condyles at the back of the base of the skull, united to each other inferiorly in a way that is closely paralleled in some mammals. The occiput is triangular and more or less concave. It lacks the large lateral foramen which distinguishes the occiput in the carnivorous Cynodontia. Externally at the sides of the occiput there is a deep notch where the squamosal bone is given off to the zygoma. The malar bone extends behind the orbit as in the mammals, and unites with the squamosal to form the larger part of the zygoma, developing a small descending process. The hard palate formed of the maxillary and palatine bones terminates in the middle of the molar region. Behind this, sharply distinguishing the palatal region from that of the mammals, there is a transverse descending arch apparently composed of the transverse bones, extending downwards so that it abuts against the rami of the mandibles, as in the Crocodilia, Rhyncocephalia, and Lacertilia. The most important resemblance to the Cynodontia is the degenerate condition of the quadrate bone, which, in the words of Seeley, "appears to be reduced to a small ossicle imbedded in the squamosal bone, but exposed in its posterior aspect behind the articular condyle of the lower jaw, into which it appears to enter."

The dentition is highly specialized. The incisor teeth are small and pointed. The canines are reduced in Microgomphodon, practically resembling the incisors. In other forms they are large, compressed, with serrated margins, as in the cyno-

donts. The homologies of this tooth in Tritylodon are uncertain. The premolar teeth are small and circular, usually tuberculate, but occasionally the first tooth is compressed laterally. The

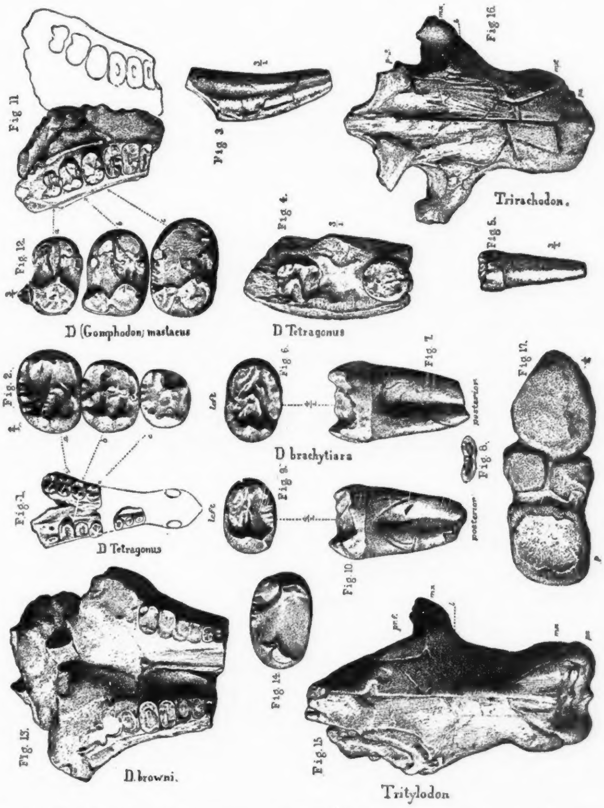

Fig. 12. — Dental and cranial structures of the Gomphodontia. *D. masticus*, analogous to a low-crowned trituberculate, like Arctocyon. *D. tetragonus*, trituberculate structure more obscure. *D. brachytiara*, resembling the lower molars of Microlestes from the Rhætic of Germany, showing the incipient division of the fang. The skull of Tritylodon is greatly reduced. (After Seeley.)

molar teeth are usually single rooted, arranged in close-set series, which diverge sharply outwards as they extend backwards; with grinding surfaces varying in form and character, but with internal and external cusps more prominent than the

other tubercles of the crown. It is important to direct attention to this divergence of the dental series posteriorly, which shows that these animals are not typical multituberculates like Tritylodon, in which animal the dental series are parallel with each other as an adaptation to the forward and backward motion of the jaws. The lower jaws are formed, as in the theriodonts, by rami which are coalesced at the symphyses, consisting externally of dentary bones which are produced posteriorly into a high coronoid process, and exhibit also an inferior posterior angle, a character which is entirely wanting in the Eocene Multituberculata. As in the cynodonts and typical reptiles, the jaws unite with the skull by elongate articular bones.

So far as known (1895), there are no fundamental differences in the skeleton to separate the Gomphodontia from the Cynodontia, and these two groups are regarded by Seeley as related in the same way as are groups of marsupials with similarly differing dentition. The skeleton doubtfully referred to Microgomphodon shows a distal transverse expansion of the ribs into triangular extremities, as in Cynognathus, so as to form an interlocking union similar to that of the zygapophyses on the neural arch. In the same skeleton the pelvis resembles that of the Cynodontia, except in the apparent exclusion of the pubic bone from the acetabulum. For in the Cynodontia the pubis takes its normal part in forming the acetabulum. The long, lateral trochanter of the femur is less developed than in the Cynodontia. In the tarsus the astragalus and calcaneum are both large bones, but the calcaneum exhibits no tuber calcis. The scapula is constructed on the same plan as in Cynognathus. The same is true of the humerus. The interclavicle is thin, wide, and long.

Tritylodon.

The skull of *Tritylodon longævus*, described by Owen in 1884, was placed hesitatingly with the Jurassic and Eocene Multituberculata until reëxamined by Seeley in 1892 (1895, 2, p. 1025). He refers the skull to the Lady Frere level, and finds some evidence that the orbit was closed posteriorly, as among the theriodonts, Professor Owen having assumed that

the orbit was open behind. He further observes the narrowing of the skull in front of the orbits and the bulbous aspect of the snout as a more definite character relating Tritylodon to the other theriodonts. As regards the enlarged front teeth, which have hitherto been considered as incisors, he thinks it is possible, since their roots ascend into the maxillary, that they may be canines. The skull further agrees with that of the theriodonts in the terminal position of the anterior nares and in the median anterior process of the premaxillary, which forms an internarial septum, also in the position of the posterior nares opening between the hinder molar teeth. The most characteristic region of the theriodont skull is that bordering the orbit, in which, unfortunately, the type specimen of Tritylodon is imperfectly preserved, so that it is impossible to determine positively whether there was a postorbital bar composed of the postorbitals (postfrontals, Seeley) as in the Theriodontia; the fossil shows an oblique fracture at this point, and the converging plates, described by Owen as the parietal bones, are regarded by Seeley as the posterior processes of the postfrontal bones, because they are closely comparable to the similarly placed bones of the theriodonts. The prefrontal bone, on the other hand, appears distinctly as forming the antero-superior border of the orbit. "Hence," Professor Seeley concludes, "I believe that the remains of the skull go to show that Tritylodon was a reptile, and that the skull might be restored upon the theriodont plan." In the same paper Professor Seeley figures (1895, 2, p. 1028) a portion of the lower jaw.

Diademodon.

This genus was founded by Seeley on the characters of the molar teeth (1895, 3, p. 1030, Pl. LXXXIX, Fig. 11). He describes the superior molars as wider than the inferior, with the crown low, subquadrate, or transversely oval. As pointed out by the writer in *Science*, these upper teeth are of extraordinary interest, since they show *the typical tritubercular pattern.* While the crown is roughly tubercular, the four prominent cusps correspond with the protocone, paracone, metacone, and hypo-

cone, respectively, the last being much the smallest, and there are two irregular intermediate cusps which represent the conules.

These characters are fairly well seen in the species *D. tetragonus*, discovered in 1884, the type being a small skull about three inches in length. In Seeley's language (1895, 3) the general effect of this cuspidate structure is that there is a sharp cuspidate girdle surrounding the subquadrate or subovate crown, with one cusp strongly developed on the outer margin, and two strongly developed on the inner margin. He found no remains of incisor teeth in this specimen, although they may have been present. Probably associated with this type were two small canines; the reference of these teeth, however, is doubtful. There may have been three small teeth in the position of premolars and seven in the position of molars, although the fragments only indicate five.

There were two isolated molar teeth found at the same time (represented in *loc. cit.*, Pl. LXXXIX, Figs. 6–9), of very small size, which Professor Seeley doubtfully proposed as the type of the distinct species *D. brachytiara*. These teeth are extraordinarily similar to those of Microlestes of the Rhætic of Germany, hitherto regarded as a typical multituberculate related to the Plagiaulacidæ.

It is the species *D. mastacus*, however (*loc. cit.*, Pl. LXXXIX, Figs. 11, 12), which presents the significant resemblance to the tritubercular pattern in its molar teeth above mentioned. In fact, while not specifically mentioning these strong tritubercular resemblances, Seeley observes (1895, 3, p. 1037): "There is nothing with which these teeth can be compared, except the molars of some of the higher groups of mammals." The teeth, however, have but one root and belong to skulls which are undoubtedly theriodont.

In the species *D. Browni* the crown is of a still simpler tubercular pattern, with one large internal and evidences of two external cusps.

General Conclusions.

It is obvious that we must await a more complete knowledge of the skeleton of these various forms before we can confidently either classify them or establish their relations to Mammalia. The literature is in considerable confusion, and requires a more careful and exhaustive revision than I have been able to give it. It appears that the mammalian resemblances of these animals include a very large number of characters which are observed without exception in the basal Eocene or Puerco fauna of North America.

The anticipation of the triconodont and multituberculate type of dentition of the Jurassic period is remarkable. If actually phyletic, it points to an extremely early divergence of these dental types — much earlier than the period of the Protodonta.

The general resemblances with existing and basal Eocene types of mammals may be summed up as follows:

Theriodont Characters.	*Promammalian Characters.*
1. Teeth heterodont, four series; molars single rooted or with grooved fangs of triconodont and multitubercular type.	1. Same characters observed in Protodonta, Multituberculata, and Triconodonta, except that the latter have completely paired molar fangs.
2. Anterior nares terminal. Posterior nares placed far back and roofed over by palatines and maxillaries.	2. The same in basal Eocene mammals.
3. Nasals narrow anteriorly, expanding posteriorly.	3. The same in basal Eocene mammals.
4. Separate prefrontals; separate postorbitals closing orbits posteriorly.	4. No prefrontals or postorbitals. Orbits open posteriorly in all basal Eocene mammals.
5. A single infratemporal or *zygomatic* arch consisting of malars and squamosals (or consisting of fusion of upper with lower arches, Baur, Case).	5. An infratemporal or zygomatic arch only.
6. Quadrate reduced and overlapped by squamosal.	6. Quadrate probably coalesced with squamosal, occasionally separated by reversion (Albrecht).

Theriodont Characters.	*Promammalian Characters.*
7. Separate transversum as in Reptilia and a distinct prevomer in certain types.	7. Transversum and prevomer missing.
8. Paired exoccipital condyles with prominent median basioccipital element.	8. Paired condyles on exoccipitals only, with basioccipital element reduced.
9. Lower jaw composite, including dentary, articular, angular, and splenial.	9. Lower jaw composed of a single bone.
10. Cervical vertebræ with intercentra.	10. Cervicals and dorsals with embryonic intercentra in Insectivora.
11. Cervical ribs separate, suturally united with vertebræ.	11. The same in monotremes and embryos of higher mammals.
12. Anterior dorsal ribs intervertebral in position with head intercentral and tubercle neurocentral.	12. The same.
13. Scapular arch with clavicles and interclavicles; epicoracoid united by suture with the metacoracoid; prescapular spines.	13. The same in monotremes; clavicles and interclavicles wanting in higher types. Prescapular spines in monotremes.
14. Pelvic arch with ischio-pubic symphysis and rudimentary obturator foramen; acetabulum closed; pubic bones secondarily developed.	14. Pelvic arch with closed acetabulum, ischio-pubic symphysis, and large obturator foramen.
15. Carpus and tarsus imperfectly known.	15. Carpus with os-centrale; tarsus with os-tibiale.
16. Humerus with powerful deltopectoral crest, and entepi- and ectepicondyles; entepicondylar foramen.	16. The same in all basal Eocene mammals.

Important, also, among the resemblances between the Theriodontia and Mammalia is the general body form, so far as it is known in the former, the proportions of the limbs to the back, and the apparent elevation of the body considerably above the ground. This, taken together with the peculiar specialization of the teeth into carnivorous and herbivorous types, indicates that the Theriodontia filled somewhat the same rôle in the economy of nature as is filled by the Mammalia at the present time. The most striking general difference is the very large size of several of these animals, such as Cynognathus.

We had rather anticipated from our knowledge of the earliest Stonesfield mammals that their reptilian ancestors would be very small. The large size of these Permian theriodonts, however, is not incompatible with the hypothesis that smaller and less specialized members of the group may have constituted a persistent phylum.

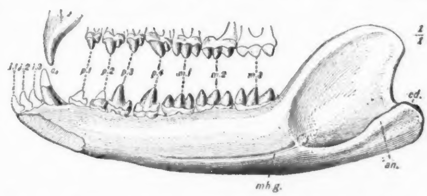

Fig. 13.—Triconodon, a typical triconodont from the Upper Jurassic, Purbeck Beds of England. (Original from specimens in the British Museum.)

The reëxamination of the jaws of the Upper Triassic Dromotherium and Microconodon fails to reveal any evidence of a composite nature, that is, so far as it is possible to determine; the jaws consist of single bones, but they are so small that this evidence is not conclusive. The position of the Protodonta, therefore, appears to be unaffected by Seeley's discoveries. The Gomphodontia of Seeley are likewise separated from the Multituberculata of Cope by the composite nature of the jaw, but it remains to be seen how far the more recent multituberculates, such as Polymastodon, which certainly have the single jaw of the mammals, may have retained other reptilian characters in the skull.

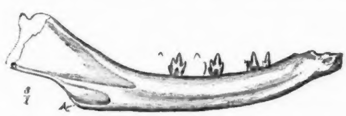

Fig. 14.—Jaw of *Microconodon tenuirostre*, a protodont from the Upper Triassic of North Carolina. *A*, supposed rudiment of angle.

We reach the general conclusion that the Theriodontia constitute a group which contains practically all the primitive characters of the Mammalia in the skeleton and teeth, and that no other reptiles or amphibians approach so near the hypothetical promammal. The explanation of the presence of amphibian characters in the soft parts of the existing Mammalia appears to be that the promammal sprang from primitive reptiles which preserved a number of still more primitive amphibian or stegocephalian characters.

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THE WINGS OF INSECTS.

J. H. COMSTOCK AND J. G. NEEDHAM.

CHAPTER III (*continued*).

VIII. THE VENATION OF THE WINGS OF DIPTERA.

In the order Diptera, as in the Trichoptera, a great reduction of wing tracheæ has taken place. Owing to this fact we have not found that any light is thrown on the question of the homology of the wing-veins by a study of the tracheation of the wings of dipterous pupæ. We will, therefore, confine our attention in this place to a study of the wings of the adult.

In this order the tendency towards a cephalization of the flight function, which occurs in nearly all of the orders of

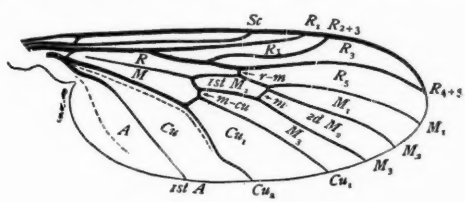

FIG. 29. — Wing of Rhyphus.

winged insects, reaches its maximum development, and has resulted in the complete suppression of the hind wings as organs of flight.

Notwithstanding this great modification of the organs of flight, the remaining pair of wings retain, in the more generalized members of the order, the primitive type of wing venation but slightly modified. So unimportant are the changes that the determination of the homologies of the wing-veins in these forms presents no difficulties.

If a wing of Rhyphus (Fig. 29) be compared with our hypothetical type (Fig. 5)[1], it will be found to correspond very

[1] *American Naturalist*, April, 1898, No. 376, p. 251.

closely with it, the only differences being due to a slight reduction in the number of the veins ; the radial sector is reduced to a two-branched condition, the media is only three-branched, and only one of the anal veins is well preserved.

Although it is an easy matter to determine the homologies of the wing-veins in a generalized form like Rhyphus, it would be exceedingly difficult, if not impossible, to do this in the case of some of the more specialized forms if they alone were studied. But when a carefully selected series of forms is examined the difficulties vanish.

We wish now to call attention to such a series for the double purpose of demonstrating the homologies of the wing-veins in the more specialized forms and of showing the value in taxonomic work of the characters presented by the wings.

It should be borne in mind that the different parts of the wing may be modified more or less independently. Although the wing acts as a whole as an organ of flight, any change in the habit of flight is likely to result in a greater modification of some one part than of others. Thus we may find that in one line of descent a certain part is greatly modified and another part remains but slightly changed from the primitive type ; while in another line of descent the opposite may be the case. It is necessary, therefore, in discussing the changes that have taken place in the venation of the wings to treat the different veins separately. We will, however, refer to only a few of the more important of these changes, as a series of figures illustrating the homologies of the wing-veins of each of the families of this order has already been published by one of us.[1]

The reduction of the radial sector. — In a few genera of flies the radius retains the primitive, five-branched condition ; of these the genus Protoplasa of the Tipulidæ is a good example.[2] But usually the number of the branches of this vein is reduced by a coalescence of some of the branches of the radial sector. Thus in many families the radial sector is three-branched, in others it is only two-branched, and in the gall-

[1] Comstock, *Manual for the Study of Insects*, pp. 413–489.

[2] *Loc. cit.*, Fig. 504.

gnats (Cecidomyiidæ) it is reduced to a simple, unbranched condition.[1]

As this variation in the number of the branches of this vein is due to a greater or less degree of coalescence among them, it is evident that here is a character of considerable taxonomic

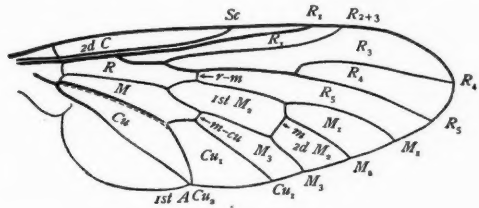

FIG. 30. — Wing of Leptis.

importance, serving as it does to indicate degrees of divergence from the primitive type.

Not only do we find differences in degree of reduction of this vein, but differences in the method of reduction are also shown. If the wing of Leptis (Fig. 30) and of Dixa (Fig. 31) be compared it will be seen that although in each the radial sector is only three-branched, the reduction has been brought about in a different way in the two genera. In Leptis veins

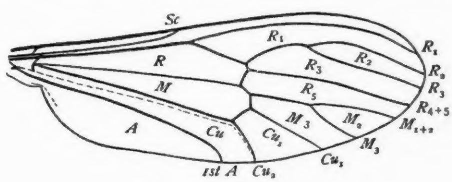

FIG. 31. — Wing of Dixa.

R_2 and R_3 coalesce; while in Dixa it is veins R_4 and R_5 that have grown together. This is a difference in kind of specialization, which indicates that the two forms belong to different lines of descent. The common progenitor of these two genera had a four-branched radial sector; in some of the descendants of this primitive form one method of reduction has taken place, while in other descendants another method has been followed.

[1] *Loc. cit.*, Fig. 522.

That this differentiation took place comparatively early in the history of the order is shown by the fact that in all Nematocera that have a three-branched radial sector veins R_2 and

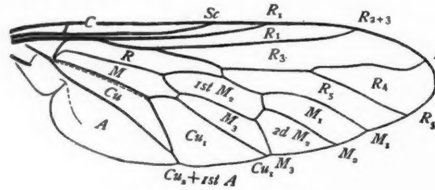

FIG. 32. — Wing of Thereva.

R_3 remain distinct; while in those Brachycera that have a three-branched radial sector veins R_4 and R_5 are separate.

The coalescence of veins M_3 and Cu_1. — One of the most characteristic methods of specialization exhibited by the Diptera is the coalescence of veins from the margin of the wing towards the base. This method of coalescence may occur between any two adjacent veins, and sometimes occurs in two or three different regions of the same wing. The most strik-

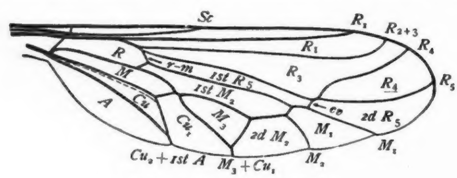

FIG. 33. — Wing of Eulonchus.

ing modifications in the courses of the wing-veins have been brought about in this way. Let us examine a series illustrating different degrees of coalescence of veins M_3 and Cu_1.

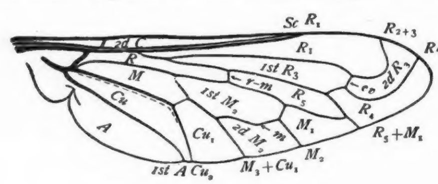

FIG. 34. — Wing of Pantarbes.

In Rhyphus (Fig. 29) these two veins retain their primitive position, extending nearly parallel and ending remote from

each other at the margin of the wing. In Thereva (Fig. 32) an approximation of the ends of these veins has taken place, which results in a narrowing of the outer end of cell M_3. In

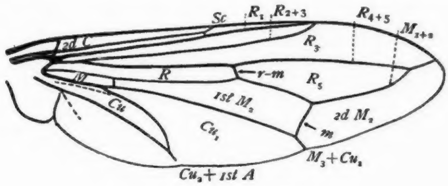

FIG. 35. — Wing of Conops.

Eulonchus (Fig. 33) the tips of the two veins coalesce, and cell M_3 is thus closed. In Pantarbes (Fig. 34) the two veins coalesce for the greater part of their length, and cell M_3 is completely obliterated.

The coalescence of veins Cu_2 and 1st A.—The second branch

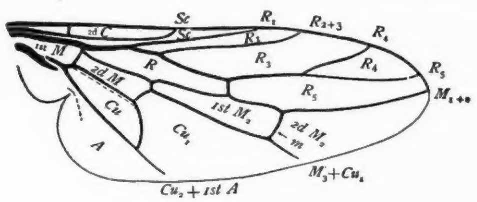

FIG. 36. — Wing of Scenopinus.

of the cubitus and the first anal vein may also coalesce in varying degrees. In Rhyphus (Fig. 29) these two veins retain their primitive position. In Leptis (Fig. 30) the tips are ap-

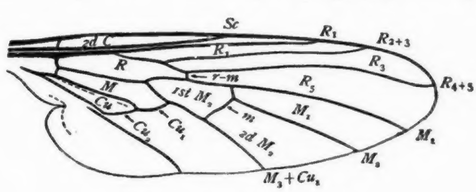

FIG. 37. — Wing of Rhamphomyia.

proximate. In Thereva (Fig. 32) the tips coalesce for a short distance. In Conops (Fig. 35) the coalescence is more striking. In Scenopinus (Fig. 36) it is carried still farther. While

in Rhamphomyia (Fig. 37) it has proceeded so far that vein Cu_2 extends towards the base of the wing, and presents the appearance of a cross-vein.

It is not strange that the homology of the branches of the cubitus in forms like Rhamphomyia was not understood until the method of study used here was employed, but now there is no doubt regarding it.

The independent specialization of different parts of the wing can be seen by comparing members of the two series given above. Compare, for example, Thereva (Fig. 32) with Pantarbes (Fig. 34). If one were to consider only the degree of coalescence of veins Cu_2 and *1st A*, Thereva would be considered the more highly specialized of the two genera, for in this genus these two veins coalesce for a considerable distance, while they are still distinct in Pantarbes. But if the degree of coalescence of veins M_3 and Cu_1 be considered the opposite conclusion would be reached, for in Pantarbes these veins coalesce for the greater part of their length so that cell M_3 is completely obliterated, while in Thereva these veins are still distinct. No better evidence could be desired for showing the impossibility of arranging animals in a natural linear series. And it is not too much to hope that an exhaustive study along these lines will serve to determine the phylogeny of the families of this order.

Entomological Laboratory,
Cornell University, April, 1898.

CLASSIFICATION OF THE AMIOID AND LEPISOSTEOID FISHES.

O. P. HAY.

THE science of ichthyology has within recent years been greatly enriched by the publication of the volumes of Mr. A. S. Woodward's *Catalogue of the Fossil Fishes in the British Museum*. This work is destined not only to give a great impetus to the study of fossil fishes, but also to have an important influence on the higher classification of the living forms. Many changes, based in part on the distinguished author's own researches, in part on the investigations of others, have been made in the ichthyological system, so that we now get new and clearer views of many groups. The author's conclusions, too, are so modestly set forth that others cannot afford to be dogmatic when they differ from him.

A large portion of the third volume of Mr. Woodward's work is devoted to the elucidation of those fishes which have for some time been regarded as forming the groups called "Amioidei" and "Lepidosteoidei." These groups are rejected by Mr. Woodward and the genera are redistributed. Catopterus and its ally Dictyopyge are made a family of the Chondrostei, while Pholidophorus and a number of related genera are removed to the Isospondyli. With this disposition of these forms no one will probably find fault.

The remaining materials are then divided into two suborders, the Protospondyli and the Aetheospondyli. The living representative of the former group is Amia; that of the latter is Lepisosteus. Mr. Woodward says (3, p. xxii): "It is equally impossible to justify the conceptions of the groups 'Lepidosteoidei' and 'Amioidei,' most of the extinct fishes which are commonly ascribed to the former being proved in the catalogue to be much more closely related to the latter."

It is the purpose of the present paper to consider the correctness of Mr. Woodward's disposition of the fishes here referred to.

The basis for the establishment of the two new suborders is found in the condition of the vertebral axis. In both groups the notochord may or may not be persistent. In the Protospondyli, if the notochord is "more or less replaced by vertebræ, the pleurocentra and hypocentra in part of the caudal region remain distinct even when fully developed." In the Aetheospondyli, on the other hand, we find the "pleurocentra and hypocentra usually fused, never forming alternating disks or rings." In fact, in all the genera admitted to the latter suborder this fusion of vertebral elements has occurred, while all genera devoid of what are regarded as pleurocentra and hypocentra, or, possessing them, do not have them fused, are relegated to the Protospondyli. That is, there are no Aetheospondyli with distinct pleurocentra and hypocentra. Furthermore, two genera which technically belong to the Aetheospondyli are referred justly, no doubt, to the Protospondyli. These are Histionotus and Neorhombolepis. We have no evidence whatever presented that they possess, even in the tail, distinct and alternating pleurocentra and hypocentra.

A word may be permitted at this point regarding relation of the pleurocentra and hypocentra to the notochordal sheath. Mr. Woodward constantly speaks of these elements as being developed in the sheath of the notochord.[1] This, so far as the Teleostomi are concerned, is an error, as has been demonstrated by the observations of many investigators. In the elasmobranchs the vertebral centra are formed principally from cartilage which has invaded the inner sheath of the notochord, and this cartilage may undergo extensive calcification. The same appears to be true of the vertebral axis of the Dipnoi. In the Teleostomi no cartilage develops within the notochordal sheath; neither do the ossifications of the vertebral centra originate there. If the sheath ever becomes ossified it is a secondary process.

It is evident that Mr. Woodward regards as a pleurocentrum any ossification in or in contact with the dorsal portion of the notochordal sheath. He would probably further limit the definition to ossifications arising distinct from the bases of the

[1] See pp. 80, 132, 164, 190, 195, 287, 374.

neural arches. Any similar ossification on the ventral side of the notochord would, I suppose, be regarded as a hypocentrum. At least, no other elements are mentioned as occurring and taking part in the formation of the vertebræ. It is nevertheless true that other elements do exist, and in many fishes enter into the construction of the definitive vertebral centra. These elements, known in their primitive condition as intercalated cartilages, are present in Acipenser and in Polyodon and remain permanently distinct.

In my investigations on the vertebral column of Amia,[1] I showed that these intercalated elements are of the greatest

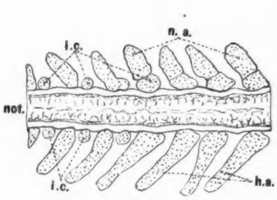

FIG. 1.

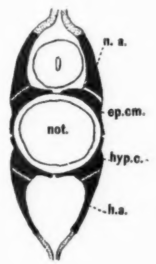

FIG. 2.

FIG. 3.

FIG. 1. — Longitudinal section of vertebral axis of young Amia, taken a little to one side of the mid-line. *i.c.*, intercalated cartilage; *n.a.*, neural arches; *h.a.*, hæmal arches; *not.*, notochord. At the right hand of the figure the upper intercalated cartilages have pushed themselves under and support the neural arches. In this region, also, the lower intercalated cartilages are wanting. The figure is from a section in the tail where vertebræ of the ordinary form change to those consisting of two distinct rings.

FIG. 2. — A diagrammatic section across one of the arch-bearing vertebral rings of the tail of young Amia. The dotted areas represent cartilage; the black represent the layer of bone covering the underlying cartilage. *ep.cm.*, the epicentral ossifications; *hyp.c.*, the hypocentral ossifications; *n.a.*, neural arch; *h.a.*, hæmal arch; *not.*, notochord.

FIG. 3. — A diagrammatic section through one of the archless vertebral rings of young Amia. *pl.c.*, pleurocentral ossifications; *hm.*, hæmacentral ossifications. Union of the four ossifications will produce a complete ring.

importance in the formation of the adult vertebral centra. I discovered that in the tail region there are, for each muscular segment, eight cartilages, *viz.*, the bases of the two halves of the upper arch, the bases of the two halves of the lower arch, a right and a left upper intercalated cartilage, and a right and a left lower intercalated cartilage (Fig. 1). At a certain stage ossification starts on the surface of each of these cartilages.

[1] Publications of Field Columbian Museum, *Zool. Ser.*, vol. i, No. 1.

Those ossifications starting from the bases of the arches, upper and lower of each segment, extend themselves (Fig. 2) and finally unite and form a ring of bone around the notochord, and lying outside of its sheath. This ring is the so-called "hypocentrum," supposed hitherto to arise from the upward growth of elements situated on the lower side of the notochord. The ossifications connected with the four intercalated cartilages (Fig. 3) spread until they meet, and thus produce another ring of bone around the notochord, the so-called "pleurocentrum," hitherto held to be the product wholly of elements situated on the upper side of the notochord. It thus becomes evident that each of the two rings of the muscular segment has another pair of elements entering into its composition besides the pair usually attributed to it. It may further be seen that the element which develops from the bases of the upper arch, the epicentrum, may easily be mistaken for the true pleurocentrum, which in reality has its origin in the upper intercalated cartilages.

In the abdominal region of Amia I found that the lower intercalated cartilage is apparently wanting. On the other hand, the upper ones, which give rise to the pleurocentra, become greatly expanded, push themselves under the bases of the upper arches immediately behind, and suppress the ossifications that might be expected to arise there (Fig. 4). The pleurocentra thus come to support the upper arches, and, growing downward, coalesce with the up-growing hypocentra to form the completed vertebral centrum. It will be seen that in Amia there are three kinds of vertebral rings, *viz.*, those formed from the union of the bases of the upper arches with the bases of the lower arches, those from the intercalated cartilages, and those partly from bases of lower arches and partly from the upper intercalated cartilages.

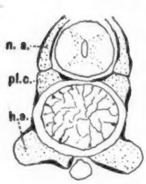

FIG. 4.—Section through an abdominal vertebra of young Amia, 23 mm. long. *h.a.*, base of hæmal arch = hypocentrum; *pl.c.*, pleurocentrum bearing the neural arch, *n.a.*

Now, how does ossification take place in the vertebral column of Lepisosteus, the living representative of the Aetheospondyli? Certain stages have not yet, so far as I am aware, been worked

out, but enough seems to be known to enable us to reach fairly good conclusions. It appears that in an early stage the notochord with its sheath becomes surrounded by a tube of cartilage.[1] The bases of the upper and the lower arches are continuous with this tube (Fig. 5, *h.a.*). Midway between the bases of the successive arches the tube becomes thickened into a ring (Fig. 5, *i.c.*), while on each side, just between the base of each upper arch and that of the corresponding lower arch, there is a gap in the cartilaginous tube. Now, it appears to me quite certain that the thickened ring of cartilage is composed of the four coalesced intercalated cartilages; and Dr. Gadow and Miss Abbott entertain the same view.[2] The tube is produced by the coalescence of these with one another and with the bases of the arches. When ossification sets in, the bony centers spread over the cartilage, probably from the bases of the arches, and, forming a ring, bind the arcualia of each segment together. No separate ossifications develop in the rings of intercalated cartilages, but these become divided each into an anterior and a posterior half, the anterior half forming the posterior end of the vertebra in front, the posterior half the anterior end of the vertebra behind. In Lepisosteus, therefore, the vertebral elements derived from the bases of the arches gain complete ascendency over the intercalated elements; in Amia, at least, the upper intercalated elements remain distinct and take a prominent part in the formation of the centrum.

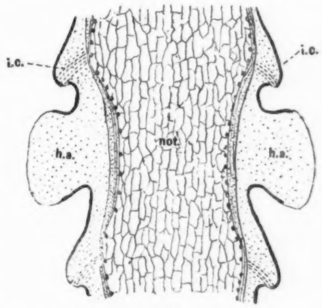

Fig. 5. — Horizontal section through notochord of young Lepisosteus. After Balfour. Cartilage is dotted; the bone shown by heavy black lines. *h.a.*, the bases of the hæmal arch: *i.c.*, the ring of coalesced intercalated cartilages. They are represented as undergoing transverse division.

There is nothing to indicate that the vertebral rings of any of the genera assigned by Mr. Woodward to the Aetheospondyli have had a mode of development essentially different from that

[1] Balfour and Parker, *Development of Lepidosteus*, Mem. Ed., vol. i, p. 785, pls. xli, xlii.
[2] *Phil. Trans. Roy. Soc.*, vol. clxxxvi, p. 214, 1895.

of our Lepisosteus. Their vertebral centra have probably been produced by the fusion of the ossifications arising in the upper arches with those of the lower arches. We do not need to disturb these genera.

Among the Protospondyli we find the nearest allies of the Amiidæ in the family Eugnathidæ. Here we discover abundant evidences of the presence of true pleurocentra. They are shown to be such by the varying positions of the neural arches on them. Neural arch and epicentrum, being ossified portions of the same arcuale, to use Gadow's convenient term, remain in direct contact, even when not coössified. When the epicentrum

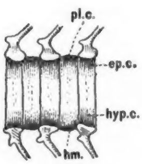

FIG. 6.

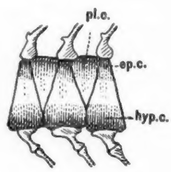

FIG. 7.

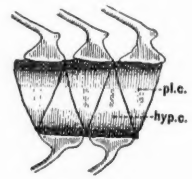

FIG. 8.

FIG. 6. — From tail of Eurycormus. After Zittel. Shows the arch-bearing rings formed by union of epicentra, *ep.c.*, and hypocentra, *hyp.c.*; also the archless rings formed by union of pleurocentra, *pl.c.*, and hæmacentra, *hm.*

FIG. 7. — From abdominal region of Eurycormus. After Zittel. Hæmacentra wanting.

FIG. 8. — From abdominal region of Callopterus. After Zittel. Both hæmacentra and epicentra are aborted, leaving only the pleurocentra, *pl.c.*, and the hypocentra, *hyp.c.* This represents one stage in the abdominal region of Amia.

is not developed, the pleurocentrum may wholly or only partially push itself under the arch. Whenever we find two distinct rings for each segment, the upper and the lower arches are connected with the same ring, as shown in Fig. 6, which represents the vertebræ in the tail of Eurycormus. In the abdominal region of Eurycormus the arch-bearing ring is apparently complete and carries the arches, while the pleurocentra are wedged in between them (Fig. 7); but the hæmacentra, which make up the lower half of the archless rings in Fig. 6 (*hm.*), are wanting. A little further reduction of the epicentra leads to the condition found in Callopterus (Fig. 8) and some of the species of Caturus. We may be sure that species of Caturus which have not yet revealed ossified vertebral elements nevertheless possessed these elements in some form, though possibly only

feebly ossified. Among the Macrosemiidæ, as we are informed, Ophiopsis possessed "completed annular pleurocentra and hypocentra, alternating in the caudal region." These are doubtless true pleurocentra. Mr. Woodward has presented a figure of a portion of the vertebral column of Notagogus.[1] This closely resembles that of the young Amia, as shown by my own figures (Figs. 1–4). Histionotus is not represented as possessing distinct pleurocentra and hypocentra; but the figure in Dr. Zittel's *Handbuch* (vol. iii, Fig. 231) shows each of the vertebral rings as having an oblique position, as though alternating component elements had united. Compare this figure with that of Callopterus, *Handbuch*, p. 231, Fig. 243.

In the Pachycormidæ the vertebral elements are feebly developed; at most, feebly ossified. Nevertheless, they are present in Euthynotus. If we may rely on Dr. Zittel's figure of the vertebral column of this genus, the arch-bearing rings were nearly complete; but there were small pleurocentra wedged in between them.

Taking all things together, we cannot doubt that the vertebral axis of the Amiidæ, the Eugnathidæ, the Macrosemiidæ, and the Pachycormidæ conforms to the same plan of development, and that this is quite different from that of the Lepisosteoid series.

When we come to examine the vertebral structures of the Semionotidæ and of the Pycnodontidæ, we find a very different condition. In many genera, indeed, the vertebral elements are as feebly developed as in some of the Eugnathidæ. In Lepidotus, however, vertebral rings are present; but there are no evidences of the presence of two rings for each muscle segment in any part of the vertebral column. Mr. Woodward states that the rings of Lepidotus seem to consist each of four sectors, each of which bears an arcuale. That is, they are just such rings as those which bear the arches in the tail of Amia (Fig. 2) and such as occur in Lepisosteus. We find no proofs in any member of the family that the intercalated cartilages were ossified, or that they manifested any tendency to assume special importance.

[1] *Catalogue*, vol. iii, pl. iii, Fig. 10.

I do not see how, in the pycnodonts, the expansions of the neural and hæmal arches can be regarded as essentially different from the epicentra and hypocentra of the tail of the young Amia. They are indeed continuous with the corresponding arches; but so, too, are the vertebral centra of many other fishes. We do not know that the ossifications of the arches of Lepisosteus are at any time distinct from the central ring. That the superior expansions lying upon the notochord of the pycnodonts are continuous with the upper arches is evidence that these expansions do not originate from pleurocentra. The intercalated elements appear to have been suppressed or nearly so, since the bases of the arches in some genera are suturally connected, thus contributing to the rigidity of body of these remarkable fishes.

I conclude, therefore, that we have here two distinct series of fishes to deal with. In the one series the intercalated elements are never of special importance and do not form distinct ossifications. The vertebral centra, when developed, arise principally or altogether from coalescence of the bases of the upper and the lower arches. This series will include the Semionotidæ, the Pycnodontidæ, the Lepisosteidæ, and the Aspidorhynchidæ. The other series will contain those fishes in which there is an evident tendency for the pleurocentrum to usurp the place and function of the ossifications that should arise in the bases of the upper arches. This series will embrace the Macrosemiidæ, the Eugnathidæ, the Amiidæ, and the Pachycormidæ. That is, I believe that Mr. Woodward has gone too far in his transference of genera from the Lepisosteoid to the Amioid series.

As regards the systematic value and kinship of the two groups, it seems to me that they rank no higher than suborders of a distinct order of Actinopterygia. The two suborders are more closely related to each other than to the Chondrostei, or even to the Isospondyli, although the latter order has probably taken its origin from the Amia-like fishes.

I believe that the characters on which my groups of these fishes have been founded indicate two very distinct lines of development, and lines of such a nature that when once entered

on there could have been no passage across from the one to the other. Mr. Woodward's groups appear to be based on characters which are rather degrees in the development of the vertebral rings; and, indeed, Amia, a protospondylous fish, would, according to the definitions given, belong to the Aetheospondyli had the fusion of "pleurocentra" and "hypocentra" been carried out a little further in the tail.

In both of the groups proposed there are genera in which, so far as we now know them, the tendencies of the vertebral elements had as yet hardly made themselves manifest. The Lepisosteoid series has, in its vertebral structures, remained closer to the primitive condition; and its members are, therefore, rather more "protospondylous" than those of the other group.

It may be permitted me in conclusion to correct an unfortunate error that I made in a paper contributed to the *American Naturalist*, vol. xxxi, p. 402, 1897. I there stated that the arches, neural and hæmal, originate at a later period in the development of the young fish than do the intercalated cartilages. They are developed earlier, and the error was due to a slip of the pen.

U. S. Nat. Museum,
March 22, 1898.

EDITORIAL.

A Plea for Systematic Work. — The systematist is under a cloud. At the biological station the naturalist of extensive acquaintance with species is looked upon with disdain by the budding zoologist still flushed with the pride of receiving his bachelor's degree. The systematist is considered a relic of a bygone age; a man who through lack of proper advantages is unequipped to do the superior class of work required in morphology and embryology. The new biologist, nurtured on "types," is quite contented if he labels the eggs he has collected "nudibranch" or "shrimp." If he descends to specific names, our eastern crayfish is, for him, "*Astacus fluviatilus*," and any frog is "*Rana esculenta*." Thus the reaction from the work of the species monger has led to carelessness of specific names.

Now, this is all wrong. Nothing is better known than that related species may differ considerably in morphological and physiological characters. When studies of such characters, made on unknown species, are published, they are apt to form the basis of profitless disputes due to the fact that, unwittingly, different species have been used by two or more investigators. Moreover, this neglect of specific characters leads to superficial observations, as a result of which facts of œcology and adaptation to environment go unobserved. Also, the scientific study of variation and the origin of species depends upon the observation of individual and specific characters, so that the present disregard of species is hindering the development of this new field of investigation.

One great obstacle to systematic work is partly responsible for the present neglect of such work. This is the fact that our species, particularly our marine invertebrates, are inadequately described. Even in the case of the groups which have been studied, the descriptions of species are scattered in a score of journals and separate publications, so that one cannot hope to have all at hand when one wishes to determine a form. Check-lists, however useful to determine distribution, do not meet the needs of the naturalist. Synoptic works, doing what Gould and Binney's work has done for the Mollusca of our northeastern coast, are needed likewise for other groups. Such works, which require for their highest usefulness figures of

every species and keys for their rapid determination, necessitate a thorough revision of large groups. The need of such synopses calls loudly upon the young naturalist to turn part of his attention from embryology and histology to first-class systematic work.

The reward will be worth the effort. The results are of permanent value. The demand for systematic books continues for generations after they have been published; they are always looked back to for synonymy and priority; they are not forgotten. Good synopses of species will also have their immediate value for every worker at the seashore. Thus, with the prospect of gaining permanently valuable results, and with the assurance of affecting the progress of a precise knowledge of animals and plants, and especially of paving the way for the phylogenetic studies of the dawning future, it becomes the duty and the privilege of the naturalist of to-day who is fitted for the work by preference or training to turn his attention to the more perfect description and illustration of our native fauna.

REVIEWS OF RECENT LITERATURE.

ANTHROPOLOGY.

Social Organization of the Kwakiutl Indians.[1] — The results of the investigations made by Dr. Boas during the last ten or twelve years among the Indians of the Northwest coast have been published in the reports of the British Association for the Advancement of Science, in the *Zeitschrift für Ethnologie*, and in government reports and elsewhere in this country. The present account of the social organization and the secret societies of the Kwakiutl tribe is one of the most valuable papers in the series. The Jessup Expeditions, which Dr. Boas last year led in person, are again at work in that region, and we may expect to receive a final and complete account of these coast tribes at an early day.

It is generally known that these people form, as Dr. Boas states, a distinct cultural group; they have been isolated to some extent by mountain barriers from the tribes of the interior.

This isolation, however, has not been so complete as to prevent the introduction of myths from foreign sources. As elsewhere, culture and environment are closely related. The contour of the coast, indented by fiords and protected by islands, has favored the development of navigation. Fish and marine mammalia abound in the sheltered waters. A mild climate of extreme humidity has produced a plant growth of almost tropical luxuriance. The quest for food is one requiring such little concern that the people have abundant leisure for the development of an extensive oral literature and elaborate ceremonials. These tribes are blanket Indians in more than one sense; they are clothed in blankets, and their property consists of stores of imported woolen blankets. A blanket is valued at fifty cents, which is also the conventional equivalent in Canadian money of the "skin," the standard of value of the Athabascans of the Far North.

Among the interesting conclusions reached in this paper may be mentioned the belief of the author that in the olden times the

[1] Boas, Franz. The Social Organization and the Secret Societies of the Kwakiutl Indians. *Ann. Rept. U. S. Nat. Mus., 1895.* Washington, Government Printing Office, 1897, pp. 311–738.

Kwakiutl lived in a series of village communities in which descent was reckoned in the male line. Each clan "developed a clan tradition which was founded on the acquisition of a manitou by the mythical ancestor, the manitou becoming heredity in the clan." This manitou became attenuated to a crest which no longer descended in the male line, but may be given in marriage so that it descends upon the daughter's children. The nobility includes only the heads of families who personate the mythical ancestor.

Dr. Boas declares that the custom of the potlatch, which has been frequently described, has been thoroughly misunderstood by most observers. "The underlying principle is that of the interest-bearing investment of property." Strenuous efforts are made to acquire a fortune by imposing loans which bear a ruinous rate of interest upon friends and thrusting them upon rivals.

The authentic record of the traditions and the detailed account of the ceremonies of the secret societies, with the native nomenclature, furnish valuable material for comparative studies and lay bare to us the thoughts of this group of aborigines. It is usually much easier to collect the totem post which stands before the door than to correctly record the myth which accounts for the character of that house post. Frequently the ritual is accounted for by several myths, and is therefore presumed to be older than the myths. The secret societies, by whom the rites are performed, are believed to have originated from the habits of warfare.

The work is profusely illustrated and many songs and texts are given.

The Graphic Art of the Eskimos.[1] — In an abundantly illustrated paper, Dr. Hoffman has described the graphic art of the Western Eskimos, and has shown that the Eskimos east of Point Barrow "exhibit but little artistic expression, this being chiefly confined to lines, dots, and other similar rudimentary markings which are employed almost wholly for decorative purposes." The evidence that has been accumulated proves pretty conclusively that the modern Eskimos of Western Alaska, among whom artistic expression in graphic delineation has reached its highest development, have learned to carve and etch with steel tools under the instruction of the Russians. This disposes of the theory which derives the Eskimos from the cave dwellers of Europe.

[1] Hoffman, W. J. The Graphic Art of the Eskimos. *Ann. Rept. U. S. Nat. Mus., 1895*, pp. 739–968.

The work follows along the lines of the author's previous publications relating to the pictographs of the American aborigines, and includes an account of these records and of the gesture signs in use among the Eskimos. The subject is treated comprehensively, with many comparisons to other culture groups. F. R.

GENERAL BIOLOGY.

Chemical Changes in Plant Stimulation.[1] — Hitherto we have had no test of the stimulation of a sensitive, responsive plant organ except the response itself. Czapek himself has been able to find in the terminal perceptive cells of the geotropically stimulated root no change in the protoplasm or cell sap, no visible movements in the mass, no secretory processes, no negative variation of the electric current such as the stimulated nerves of animals show, no change in osmotic cell pressure, no change in the normal, slightly acid, reaction.

The new find is a chemical change in the protoplasm. When the root-tip of a seedling of a bean or other species is boiled in an ammoniacal silver nitrate solution, there is a marked reduction of the silver, especially in the cells of the periblem. This reduction is stronger in the cells of stimulated than in those of unstimulated root-tips.

A second change consists in the diminution in the amount of a substance of the root-tip which easily loses oxygen. Such a substance is indicated in the normal root-tip by such changes as these: blue coloration (oxidation) of a section of the root-tip by an emulsion of guajac gum in water; deep blue coloration of sections by indigo white, made by careful reduction of indigo carmine by dilute hydrochloric acid and zinc; strong violet reaction (indophenol reaction) in sections subjected to an aqueous solution of α-napthol, to which paraphenylendiamin has been added. Now, all such reactions are less marked in the root after stimulation. Thus, stimulation results in increased capacity for reduction and diminished capacity for oxidation — an increased avidity for oxygen.

These changes occur long before the response of turning shows itself, occur earlier the more sensitive the root, and are less marked after a slight stimulus such as results from a slight inclination of the root from verticality.

[1] Czapek, F. Ueber einen Befund an geotropisch gereizten Wurzeln. *Ber. deut. bot. Ges.*, Bd. xv, pp. 516–520. January, 1898.

The isolation of the two substances — the reducing and the oxidizing — was now attempted. The former is not changed by boiling or by the action of chloroform, and is soluble in alcohol; the latter is destroyed by heat, is unchanged by chloroform, is insoluble in alcohol, and can be extracted from the triturated cells by water. A large number of root-tips of *Vicia faba* were first rubbed up with water until no fragments remained. The aqueous extract was filtered, and to the filtrate alcohol was added. A precipitate was formed which had all the properties of the oxidizing substance. It is highly probable that it belongs to the category of oxidation ferments. To get the reducing substance, the preceding solution was filtered to eliminate the alcoholic precipitate. The filtrate had all the properties of the reducing substance. A further study indicated that it belonged to the aromatic organic substances, many of which have an intense reducing action, and are hence used in photography.

Thus, geotropic stimulation of the root-tip produces chemical changes leading to the increase of a reducing substance of aromatic nature, and to a diminution in the amount of an oxidizing ferment.

Dissimilar Reciprocal Crosses. — It has been observed in many cases that the two hybrids A♀ × B♂ and B♀ × A♂ are dissimilar. In the current Heft of the *Jenaische Zeitschrift* is an interesting note by the late Fitz Müller-Desterro, serving to explain this phenomenon in a single case, the hybrid of *Ruellia formosa* and *R. silvaccola.* The parent flowers differ in that those of *R. formosa* are a dark, luminous red, while those of *R. silvaccola* are a clear, faint red. The hybrid *R. silvaccola* ♀ × *formosa* ♂ is of a beautiful red, more like the red of *R. formosa* than of *R. silvaccola;* and *R. formosa* ♀ × *silvaccola* ♂ is of a cloudy mixed color, with more or less extensive smutty blotches. The difference of color is due to the fact that the egg cell only, and not the male cell, transmits the chromatophores upon which the color depends; hence, the hybrid *R. silvaccola* ♀ × *formosa* ♂ received chromatophores from *silvaccola* only, while *formosa* ♀ × *silvaccola* ♂ received them from *formosa* only. (This result does not, however, fully explain the observed facts of color in the hybrid.) The important conclusion is now drawn that in this case the qualities of the hybrid depend, not alone on the germ plasm in a strict sense, but also on certain living included particles.

Scientific Agriculture. — One of the most handy books of reference which has appeared of late is Henry's *Feeds and Feeding.*[1]

[1] Henry, W. A. *Feeds and Feeding.* A handbook for the student and stockman. Madison, Wis., 1898. Published by the author. 8vo, vi + 657 pp.

Professor Henry, who is one of the ablest and most influential Experiment Station Directors in the country, treats his subject under three headings, dealing respectively with plant growth and animal nutrition, feeding-stuffs, and feeding farm animals. From his own large experience, and the voluminous literature of the Experiment Stations, he has compiled in a readily accessible but condensed form much information concerning the transmutations which organic matter undergoes from its origin in the leaves of plants to its return to the soil as vegetable or animal refuse. T.

ZOOLOGY.

The Sea Otter. — Among North American mammals doomed to practical extermination must be included the sea otter (*Latax lutris*), unless the most rigid restrictions be speedily enforced for its preservation. Formerly this animal was more or less abundant along nearly the whole Pacific coast of North America, from the Pribilof and Aleutian Islands south to northern Lower California. Indeed, the islands of southern California and northern Lower California were, about the beginning of the present century, famous hunting grounds for the sea otter. Another portion of the seaboard where great numbers were killed was the coast of Oregon and Washington, where many were taken as late as 1876. Thence northward, also, to the Aleutian Islands they were killed in large numbers for many years. Only small remnants here and there, however, at present exist along this whole stretch of coast, their extermination, from a commercial point of view, having long since been accomplished. Even in Alaskan waters, during the last half of the eighteenth century, their indiscriminate slaughter had so far reduced their numbers that toward the close of this period the then newly formed Russian American Company placed restrictions upon the number allowed to be taken, and enforced other regulations by which the females were spared, and care insured against needlessly alarming these exceedingly timid and suspicious animals. The early wholesale, unrestricted destruction of the sea otter exactly parallels that of the fur seals throughout their range, except where accorded government protection, and with the same sad result of practical extinction.

Their numbers have now become so alarmingly reduced, even in their last stronghold, the Aleutian Islands, notwithstanding attempted government restriction, that more serious measures for

their protection are now contemplated, not only in behalf of the sea otter, but more especially in behalf of the natives of the Aleutian Islands, who are almost entirely dependent upon the sea otter for the necessaries of life. The present status of this animal has hence been made the subject of a report[1] by Capt. C. L. Hooper, of the Revenue Cutter Service, to the U. S. Treasury Department, from which it appears that none now exist on the islands or shores of the mainland north of the Alaskan Peninsula ; at least the animal is not now hunted outside of the Aleutian Islands. Captain Hooper states that no reliable record of the sea-otter catch is obtainable prior to 1873. He presents, however, a tabular statement of the approximate number taken annually at the different islands by the natives from 1873–96 inclusive. The total catch for this period of twenty-four years is about 58,000, the largest number, 4152, being taken in 1885, and the smallest, 598, in 1894. This does not, however, include the considerable number killed by white hunters which yearly visit the otter banks. It is, however, a trifling number in comparison with the annual catches of a century ago.

Under this constant persecution the sea otter has not only greatly decreased in numbers, but has notably changed its habits. To quote from Captain Hooper's Report : "Being constantly harassed, clubbed, and shot on shore, caught in nets by white men, their hauling grounds made uninhabitable by the camp fires of the hunters and defiled by fisheries and the decaying bodies of their slaughtered companions, the sea otter of the Aleutian Islands has not only decreased in numbers, but has actually changed its habits. It no longer comes out upon the land to feed, rest, or give birth to its young. A floating raft of kelp serves as its only resting place and banks of thirty fathoms of water are its feeding grounds. Even there it is hunted and harassed by hunting schooners from March until August. Having been driven from the shore, it is being exterminated on the sea by a fleet of hunting schooners, and the native hunters of the Aleutian Islands are being deprived of their chief means of subsistence. In addition to its change of habits and decrease in numbers, the range of the otter is very much reduced."

[1] A Report on the Sea-Otter Banks of Alaska, Range and Habits of the Sea Otter. — Its Decrease under American Rule, and some of the Causes. — Importance of the Sea Otter to the Natives of Alaska inhabiting the Aleutian Islands. — Proposed Regulations for 1898. By C. L. Hooper, Captain R. C. S., Commanding Bering Sea Patrol Fleet, 1897. Washington, Government Printing Office, 1897. *Treas. Depart. Doc.* No. 1977. 8vo, 1–35 pp., with map.

Captain Hooper urges the enforcement of more stringent regulations respecting sea-otter hunting, not only for the purpose of preserving "the most beautiful and valuable fur-bearing animal in the world, but to preserve it for the benefit of the natives who have been dependent upon it for more than a century, and who will be reduced to suffering and want without it."

J. A. Allen.

Pacific Coast Annelids. — In the recent paper[1] by Prof. H. P. Johnson, of the University of California, we have the promise of an extension of our knowledge of the marine annelids of the western coast of North America that will undoubtedly be welcomed by students of marine zoology. This first contribution deals only with five families of the order Polychæta, *viz.*, the Euphrosynidæ, the Amphinomidæ, the Palmyridæ, the Polynoidæ, and the Sigalionidæ. The scope of the work which Dr. Johnson has laid out for himself, and the beginning of the execution of which is now presented, may be stated in his own words: "It is certainly an interesting reflection of the haphazard nature of zoological exploration to find that much more is known about the Polychæta in the most remote regions of the earth, in the farthest north and the farthest south, in the East Indies and in the South Seas, than along the easily accessible shores of a great civilized nation. No apology, therefore, need be offered for the preponderance of attention here given to such preliminary matters as descriptions of new species, distribution, habits, and other details of the natural history of the group. It is the writer's intention to present the entire order Polychæta as represented on our shores thus in outline, and concurrently or subsequently to fill in the picture with as much of embryological and histological detail as possible. The present publication is in every sense a *prodromus* of a more extensive work, which will require many years to complete."

Eighteen species in all are treated in the paper, thirteen of which are new to science. They are as follows:

Euphrosynidæ: *Euphrosyne aurantiaca*, sp. nov., *Euphrosyne arctia*, sp. nov.; Amphinomidæ: *Eurythoë californica*, sp. nov.; Palmyridæ: *Chrysopetalum occidentale*, sp. nov., Heteropale, gen. nov., *Heteropale bellis*, sp. nov.; Polynoidæ: Polynoë Savigny (Sens. ext.) (including *Lepidonotus* Leach, *Polynoë* Savigny, and *Halosydna* Kinberg), *Polynoë squamata* (L.) Aud. et M.-Edw., *Polynoë brevisetosa* Kinberg, *Polynoë*

[1] Johnson, H. P. A Preliminary Account of the Marine Annelids of the Pacific Coast, with Descriptions of New Species. *Proc. Calif. Acad. Sci.*, Ser. 3, zool., vol. i, No. 5, 1897, pp. 153–190, Pls. V–X.

reticulata, sp. nov., *Polynoë gigas*, sp. nov., *Polynoë lordi* Baird, *Polynoë pulchra*, sp. nov., *Polynoë fragilis* Baird; HARMOTHOË Kinberg (Sens. ext.) (including *Antinoë*, *Harmothoë*, *Hermadion*, Kinberg; *Eucrante*, *Eunoa*, *Evarne*, *Lænilla*, *Lagisca*, *Melænis*, *Nychia*, Malmgren; *Polyeunoa* M'Intosh): *Harmothoë imbricata* (L.) Malmgren, *Harmothoë hirsuta*, sp. nov., *Harmothoë crassicirrata*, sp. nov.; Sigalionidæ: PEISIDICE, gen. nov., *Peisidice aspera*, sp. nov., *Sthenelais fusca*, sp. nov., *Sthenelais verruculosa*, sp. nov.

Concerning the classification of the polynoids, the author tells us that he has been strongly tempted to follow the more conservative students of the group and place the forms he has studied all under the type genus Polynoë; but that, after a careful study of the material at hand and the literature available, he has become convinced of the practicability of arranging nearly all the known species under two genera, *viz.*, *Polynoë* Savigny and *Harmothoë* Kinberg. He wishes it to be fully understood, however, that he regards this as provisional only.

Collections have been made at numerous points, from San Diego on the south to Puget Sound on the north. Most of the species have been collected by the author himself, and have been studied in the living condition.

Numerous interesting observations on the habits and variability of several of the species are recorded, none of which are more interesting, perhaps, than those pertaining to the commensalism exhibited by some of the species of the genus Polynoë. Thus we are told concerning *P. brevisetosa* that "probably no species of this great family, noted for the morphologic plasticity of many of its members, is more variable than this. The variation it exhibits is unquestionably due to differences in its environment." Some of the individuals are free living, while others are commensal in the tubes of species of Amphitrite and Thelepus. "Like another tube-commensal of our coast, *Polynoë reticulata*, it attains a larger size in this mode of existence than when free living, but not unless it lives in a tube of liberal dimensions, so that both the rightful occupant and its messmate have ample space." The commensal individuals are said to be proportionally longer and narrower than the free-living ones, and furthermore to exhibit certain structural peculiarities, most of which appear to be the direct result of their mode of life. The elytra are thinner and smoother, and not so likely to extend to the extreme posterior end of the body. And, what is still more significant, the elytra of the ventral series tend to develop a strong upper bristle, which the author thinks is of advantage in crawling into the tube. A very curious thing in

connection with the commensals of this species is the fact that the pigment is heavier and more uniformly distributed in them than in the free-living individuals. In another species, however, *viz.*, *P. pulchra*, which lives "as a common messmate (or possibly parasite) of two animals wide apart in the organic scale, *Holothuria californica* and *Lucapina crenulata*," the wholly hidden specimens may be destitute of pigment.

Polynoë gigas the author finds to be almost always asymmetrical in the arrangement of the elytra and dorsal cirri. Of nine specimens examined, only three had the same number of elytra on each side; and of these three, only one was fully symmetrical. W. E. R.

Regeneration of the Earthworm's Head. — Of late there has been a noticeable revival of the old interest in problems of regeneration of lost parts in animals, but it has been rather striking that so many observers have been content to use only the old methods available before the present era of microtome and perfected staining technique. In contrast to them comes the second part of the investigations of Dr. K. Heschler,[1] who studies by serial sections the newly forming heads in nearly one hundred earthworms from which the first four or five segments had been cut off.

Some of the results obtained are briefly noted below, but it should be kept in mind that the author does not claim to have exhausted the most difficult question of the histology of regenerating organs in the earthworm, and that he freely concedes that the interpretation of the confused and complex masses of tissue we find in these regenerating heads has a large subjective element.

During the first week after the removal of the head there is but little actual regeneration of parts. The wound heals by the formation of a cicatrix that is made up chiefly of lymph cells; but after a few hours spindle-shaped cells of undetermined origin are added to it. The epidermis grows over this cicatrix in a few days, while the intestine closes up and draws back so that the cicatricial tissue lies between its blind end and the new epidermis.

After this first period there is active regeneration accompanied by mitotic cell division. New cells — "regeneration cells" — wander into the cicatrix from epidermis, muscle, and other sources. In the complex mass so formed the new nervous and digestive organs of the head now arise.

[1] Ueber Regenerationsvorgänge bei Lumbriciden, II. *Jenaische Zeit. f. Naturwissenschaft.* März, 1898. Pls. XXI–XXVI, pp. 521–596.

The ventral nerve cord grows forward into the above mass as nerve fibers accompanied, probably, by some cells from the old cord. It is interesting to note here that the entire cord, at least as far back as the fifteenth segment, shows most active mitotic divisions of ganglion as well as of other cells. To this forward growth from the old cord is added a collection of many cells that migrate in, separately, from the new epidermis that grew over the cicatrix. These cells furnish the main part of the new brain.

The new epidermis over the cicatrix grows backward as a small funnel, which meets the old intestine as it elongates into the new tissue. The ingrowth ultimately opens into the old intestine and is thought probably to form the digestive tract in the new head as far back as the fourth segment, where the new pharynx will be formed from the old intestine.

The making of a new head in the earthworm thus involves elongation of old organs, transformation of some of them, and in the case of the nervous system marked change of activity even in parts remote from the wound; in addition there is a large element of new formation from cells of an embryonic and undifferentiated character.

E. A. A.

Two Papers on the Finer Structure of Nerve Cells. — Students of neurology are indebted to Prof. A. van Gehuchten for an excellent *résumé*[1] of the more recent work on the finer structure of the nervous cell. The paper was prepared as a report for the Twelfth International Congress of Medicine, held at Moscow in August, 1897. After a brief introduction the subject is dealt with in four chapters as follows: the internal organization of nervous cells, changes which accompany their different states of activity, changes from lesion of the axis-cylinder process, and changes from disturbances in the circulation and from poisons. The paper is illustrated by one plate, and the numerous bibliographical references are gratifying. It is to be regretted that the medical influence has asserted itself to such an extent that the report treats almost exclusively of the nervous cells of vertebrates.

Prof. C. F. W. McClure[2] has undertaken the study of the finer structure of the nerve cells in the invertebrates on lines inaugurated

[1] Gehuchten, A. van. L'Anatomie fine de la cellule nerveuse. *La Cellule*, tome xiii, pp. 313–390, 1897.

[2] McClure, C. F. W. The Finer Structure of the Nerve Cells of Invertebrates. I. Gasteropods. *Zool. Jahrb., Abt. f. Anat. u. Ontog.*, vol. xi, 1897.

for the vertebrates chiefly by Nissl, and gives in the first of what promises to be a series of contributions to this subject an account of the nerve cells of certain gastropods: Helix, Arion, and Limax. Exclusive of nuclei, the bodies of the nerve cells in these animals are composed of an apparently homogeneous ground substance containing many small granules usually arranged in rows. From the reactions of these granules to dyes, especially to methylene blue, they are regarded as similar to the chromophilous substance in the nerve cells of vertebrates. They are often grouped in spindle-shaped masses which resemble the "Körner" of vertebrate nerve cells. Fibrillæ, which differ in their staining qualities from the ground substance as well as from the granules, are believed to occur both in the bodies of the cells and in their axis-cylinder processes. In the majority of cells the fibrillæ show a concentric arrangement. The chromophilous granules form rows on or between these fibrillæ, but are not to be regarded as thickenings in the course of a fibrilla. In Helix it is interesting to note that structures comparable to centrosome and centrosphere have been identified. G. H. P.

Forestal Zoology. — Under the title *Forstliche Zoologie*,[1] Dr. Eckstein, Docent at the Forestry School of Eberswalde, publishes a manual of zoology as viewed from the standpoint of the student of forestry, in which not only the animals themselves, but the effects that they produce on plants are described and figured.

Zoological Notes. — The Report of the U. S. Commissioner of Fish and Fisheries for the year ending June 30, 1897, recently issued, contains as an appendix of 340 pages, with 80 plates, a comprehensive manual of fish culture, based on the methods of the United States Commission.

Dr. Ludwig Plate has described,[2] under the name *Macrophthalmia chilensis*, an interesting cyclostome. This form comes from fresh water, is about three feet in length, with compressed form; bluish black above, silvery white beneath. The most important structural features appear to be the large and well-developed eyes, much like those of teleosts, and the nasal opening not at the tip of a nasal papilla. There are seven gill openings; the teeth of the oral hood are simple and more like those of Myxine than those of Petromyzon. A full anatomical description is promised later.

[1] Eckstein, Karl. *Forstliche Zoologie.* Berlin, Parey, 1897. 8vo, viii + 664 pp., ff. 660.

[2] *Sitzungsberichte d. Gesellsch. f. Naturf.* Berlin, Freund, 1897.

Dr. Franz Werner, in *Verhandl. zool. bot. Gesell. Wien*, xlviii, 1, gives an interesting summary of our knowledge regarding the breeding habits of amphibians. The author calls attention to the fact that most of the forms inhabit tropical America. A bibliography is appended.

It appears from a recent number of the *Mededeelingen van het Proefstation Oost-Java* that in that part of the world tailor birds are found to be injurious to the fields of sugar cane.

The recent discovery by Mr. James P. Hill,[1] that the marsupial genus Perameles has a true allantoic placenta, is one of the most important in regard to the mammals in recent years, possibly since the discovery of the oviparous nature of the monotremes, pointing, as it does, to the idea that the marsupials have descended from a placental stock.

BOTANY.

The Floral Plan of the Cruciferæ. — When the great number, wide distribution, and habital diversity of the Cruciferæ are considered, it is remarkable that the floral structure is well-nigh constant throughout the whole family. So uniform, in fact, are the flowers that the systematist has always been puzzled to find in them clear or satisfactory distinctions for tribal subdivision. Within a four-membered calyx are four petals, alternating with the sepals, then two short lateral stamens, two pairs of longer, somewhat approximated stamens approaching the median line, and, finally, a two-celled gynœcium with lateral valves and median "false" septum. Departures from this well-known plan are chiefly of the nature of simplification through reduction or abortion of parts.

On a casual inspection, the typical cruciferous flower would seem to be simple enough except in its hexandrous andrœcium, but its plan, even after exhaustive research and prolonged discussion, is still a matter of doubt, and each whorl of floral organs has been subject to widely divergent interpretation. Among the numerous investigators, who have published upon the cruciferous flower, may be mentioned A. P. De Candolle, Kunth, Bernhardi, Steinheil, Hochstetter, Krause, Wydler, Payer, Chatin, Godron, Eichler, Duchartre, Wretschko, Fournier, Engler, Klein, Celakowski, Chodat, and Lignier. Of these

[1] *Quar. Journ. Micros. Sci.*, vol. xl, p. 385.

writers, Eichler has, after an admirable summary of previous work upon the subject, stated the simplest and perhaps most convincing plan. His diagram, which has in recent years met with pretty wide acceptance, is as follows: the calyx consists of two dimerous alternating whorls; the corolla of a single tetramerous whorl, of which the parts alternate with the sepals taken together; the andrœcium of two dimerous whorls (the members of the inner being doubled by division), and the gynœcium of two laterally placed carpels.

This theory is too well known and has been too carefully grounded to need any explanation or defense here. In recent years, however, three more or less divergent views have been expressed by Klein, Celakowski, and Lignier. Passing over some slight points, one may say that the plan of Klein differs from that of Eichler in maintaining a tetramerous inner whorl of stamens and a four-carpelled gynœcium, in which not only the two valves, but also the two placenta-bearing columns of the replum, represent carpels. Celakowski, however, believes the andrœcium to be derived from two tetramerous alternating whorls, the outer of which has lost two of its members by abortion. He agrees with Eichler and most of the earlier writers in regarding the gynœcium as fundamentally bicarpellary.

Lignier[1] has suggested a theory of which the ingenuity is only exceeded by the disregard for facts. He supposes the flower to consist of only four alternating dimerous whorls. The first consists of the two outer sepals, which he believes lateral. Then follow the two median sepals, which he regards as three-parted, the green sepal being the central part of each and the two adjacent petals being the lateral parts or lobes of the sepals. Similarly, the short stamens are regarded merely as the middle lobes of trifid members, of which the adjacent longer stamens represent the lateral parts. Even in the gynœcium Lignier endeavors to show connate three-parted members, since he regards the placentæ as the central lobes and the valves as composed of the connate lateral lobes of two carpels!

The latest publication upon the cruciferous flower is that of Chodat and Lendner.[2]

These authors have made a detailed examination of the floral development, especially as to the course of the fibro-vascular bundles, and devote some space to a refutation of Lignier's theory, — a matter of no great difficulty for any one reasonably conversant with the early stages of the cruciferous flower. The argument is chiefly

[1] *Compt. rendus. Acad. Sci.*, pp. 675–678, 1895.

[2] *Bull. de l'Herb. Boiss.*, v., pp. 925–938, November, 1897.

to the effect that the corolla arises as a distinct whorl of organs which are formed later than the inner sepals and receive bundles which leave the axis at a higher point. In the same way the long stamens are shown to be a distinct whorl and in no sense appendages of the shorter ones.

Chodat and Lendner agree in nearly all points with the view of Klein, and argue that the seemingly bicarpellary gynœcium of the normal Cruciferæ is in reality due to the union of four carpellary members. This view is based chiefly upon the course of the bundles in certain anomalous three- or four-carpelled specimens of *Cheiranthus cheiri* L. It is scarcely necessary to say that a conclusion from these rather doubtful premises must be accepted with all due caution.

B. L. R.

Zinsser on Root Tubercles of Leguminosæ. — In *Jahrb. f. wiss. Bot.*, Bd. xxx, Heft 4, pp. 423–452, may be found an interesting paper by O. Zinsser on the root tubercles of the Leguminosæ. This paper contradicts some of the statements of Frank, Gonnermann, Laurent, etc., especially the statement that the root tubercle organism occurs outside of the tubercles in various parts of the plant. This work was done in the Botanical Institute at Leipzig. The following are some of the more important statements:

1. Seeds of all sorts of leguminous plants were washed in sterile water, soaked fifteen minutes in water containing mercuric chloride (1 : 1000), washed again thoroughly in sterile water, planted in sterile earth, covered with cotton-plugged sterile bell jars, and watered with sterile water. The plants which grew from these seeds were under observation eight to twelve weeks, but in no case did any tubercles form on their roots. If, however, the contents of root tubercles of these same plants was added to the earth, tubercles developed on the roots in most cases in fourteen days. The author believes with Prazmowski that Dr. Frank's diametrically opposite results were due to the fact that he did not succeed in freeing his seeds from adhering surface organisms. So far as could be detected, the sublimate treatment did not in any way injure the plants.

2. Other aërial parts and roots destitute of tubercles were then tested in various ways for the occurrence of the germ:

(*a*) Approved staining methods, *e.g.*, carbol fuchsin, alkaline methylen blue, gentian violet in anilin water, etc., were used on sections, but in no case could bacteria be demonstrated in the tissues.

(*b*) The author washed out the contents of tubercles in water, injected this into growing stems or roots of seedlings, and after a lapse of from four to six weeks washed their surface thoroughly with sterile water, bruised them in a sterile porcelain mortar, mixed thoroughly with sterile earth, planted therein the sterilized seeds, and obtained root tubercles in three weeks on the roots of almost every plant. This would indicate that, if the germs are normally present in the stems and other non-tuberculous parts of leguminous plants, the bruised tissues added to sterile earth ought to infect the roots of seedlings grown therein. Consequently, roots, stems, leaves, and leafstalks of *Phaseolus vulgaris*, *P. multiflorus*, *Vicia sativa*, *V. faba*, *Pisum sativum*, *Ervum lens*, and *Lupinus albus* were tested in this way after cutting away the superficial portions with sterile knives, but in no case did any root tubercles appear.

(*c*) After isolating the root tubercle organism from four plants (*Phaseolus multiflorus*, *Pisum sativum*, *Lupinus albus*, and *Vicia faba*) and determining that the cultures were able to produce root tubercles on the specified plants, and would remain alive for a long time when injected into parts above ground, attempts were made to isolate these organisms from other parts of the same plants, using four different media, *viz.*: (1) sterilized hydrant water; (2) water, meat extract, peptone, and sugar in the following proportions, — 100, 0.5, 0.5, 3.0; (3) decoction of the plant mixed with washings of earth; (4) decoction of the plant, asparagin, and sugar in the following proportions, — 100, 0.25, 0.5. These nutrient solutions were sterilized in small Erlenmeyer flasks. The inoculations were made in a room rendered as free as possible of floating germs by the introduction of vapor of water. The selected, above-ground tissues were washed for a long time and very carefully in sterile water, cut into small pieces with flamed shears, and put carefully into the flasks, part of which were exposed to the air and the rest subjected to an atmosphere from which the oxygen was removed as completely as possible. Bacterial growths appeared in only a few of the flasks, and none of these produced any root tubercles when added to the sterile earth in which the seeds were grown. This experiment was repeated on roots free from tubercles with the same negative result.

(*d*) When sterilized seeds had sufficiently germinated, the roots were put through a tiny opening in the bottom of a glass pot, and then the bottom of the pot was filled with a mixture of sterilized gypsum and water, so that the middle part of the roots was cemented fast. The part of the root above the partition of gypsum was then covered

with sterile earth and watered with sterile water, the part below being put into ordinary earth mixed with bruised tubercles. The whole was then protected from air infection by a glass cover. Root tubercles formed on this lower part of the root, but none were found on the root and rootlets grown in the sterile earth. Cultures from the part of the roots grown in the sterile earth and from the parts above ground yielded negative results; bruised portions added to sterile soil also failed to cause any root tubercles on the roots of seedlings grown therein. The reverse experiment was tried, *i.e.*, using infected soil in the upper chamber and sterile soil below. In this case tubercles formed on the roots in the upper chamber and not on those in the lower one. Cultures and soil infections from these lower roots yielded negative results. These experiments indicate that the germs cannot migrate from the tubercles to other parts of the plants.

3. Mr. Zinsser determined with considerable care the length of time the root tubercle organisms of *Phaseolus multiflorus* are able to live when injected into germinating seeds, young roots, young and old stems, leafstalks, etc., of various legumes. His conclusions do not differ much from results obtained by numerous observers working with all sorts of organisms non-pathogenic to plants. In other words, they were able to retain vitality and make a feeble growth for a variable period, usually two to ten weeks, but only in close proximity to the place of insertion, the germs being injected by means of a Pravaz syringe. The infectious material was derived from pure cultures and also directly from the tubercles.

4. Water washings from the root tubercles of three different legumes (*P. multiflorus*, *V. faba*, and *L. albus*) were injected into a great variety of plants (forty-two species of many different orders), but after eight weeks the organisms were not to be found in any of them either at the point of insertion or two centimeters away. Moreover, on the roots of none of these plants could tubercles be induced, although abundant washings of root tubercles were added to the earth. Pure cultures and tubercle washings from *Phaseolus multiflorus*, *P. vulgaris*, *Vicia faba*, *Lupinus albus*, and *Pisum sativum* were also injected into the callus on cut branches of locust, poplar, and willow, but after forty days no living bacteria were to be found therein.

5. The author also tried the behavior in plant tissues of a variety of micro-organisms non-pathogenic to plants, with results much like the preceding and entirely confirmatory of what we already know, namely, that many saprophytes and animal parasites are able to live

in plants for some weeks (three to ten or more in Mr. Zinsser's experiments), and frequently make a feeble growth, especially when injected in large numbers. Mr. Zinsser's experiments include ten bacteria and were made on no less than fifty of the higher plants, Leguminosæ included, unquestionably involving an enormous amount of hard work. Pure cultures were always used. These were diluted with water and injected by means of a Pravaz syringe. In all cases the growth, if any, was restricted to the immediate vicinity of the puncture. On examination, bacteria were found only in the injured cells and in the intercellular spaces, never in the uninjured living cells as a result of their own activities. The length of time the bacteria were able to live in the tissues varied with the plants, and was different for different micro-organisms. Even the most resistant spores (those of *B. subtilis*, *B. prodigiosus*, *B. megaterium*, and *B. anthracis*) died in the plant tissues inside of eighty-six days.

6. The author did not succeed in growing the genuine tubercle bacilli on agar or gelatin prepared according to Beÿerinck's direction and Gonnermann's. On such media numerous germs were obtained from the tubercles after sterilizing their surface, but they were non-infectious, and must be considered as associate forms or secondary growths (see Beÿerinck's statements). The tubercles were sterilized by soaking ten minutes in 1 : 1000 sublimate solution, or by washing thoroughly in sterile water, soaking for a few minutes in alcohol and then burning this off. After numerous failures, the true germ was finally isolated on Winogradsky's silicate jelly. In Petri dishes on this medium at the end of eight days the colonies were small and white, grew well in the juice of the host plants, and produced tubercles on their roots. Living colonies were found in anærobic cultures at the end of three weeks. The microbe is about 1 μ long, and actively motile. Neither spores nor flagella could be demonstrated. The colonies obtained from the tubercles of different plants looked just alike, and addition of plant juices to the silicate jelly did not in any way change the appearance of these colonies. The organisms were also morphologically indistinguishable.

7. Flasks of water, sugar, magnesium sulphate, and potassium phosphate in the following proportions, 100, 5.0, 0.1, 0.1, were inoculated, put in a dark place, and aërated with air from which by passage through potash water and then through sulphuric acid all nitrogen compounds were removed. After forty-nine days these

flasks were opened. No living bacteria were present in any of them, nor were the fluids able to produce tubercles when added to the roots of plants growing in sterile earth. Under these conditions the germs were not able to assimilate free nitrogen.

8. It is not clear in just what way the tubercles originate. Their production is due to the action of specific organisms, but these are not always capable of causing them, as the frequent failures showed. The author was not able to produce them by direct inoculations, not even in the tissues of young roots and stems. He thinks that possibly infection takes place only through young root hairs. Contrary to Laurent, the time of year makes no difference; neither does the age of the plant, as Nobbe has also shown, since tubercles were obtained both on the roots of seedlings and on those of well-developed plants. Gain's observation that infections are more numerous in a damp soil is confirmed.

ERWIN F. SMITH.

Recent Studies of Asarum. — The wild gingers of the Eastern and Middle United States, concerning the specific definition of which some doubt has long been felt, form the subject of papers by Bicknell in the *Bulletin of the Torrey Botanical Club* for November last, Ashe in the first part of the current volume of the *Journal of the Elisha Mitchell Scientific Society*, and Kraemer in the *American Journal of Pharmacy* for March. In commenting on some of these papers in the *Journal of Botany* for March, James Britten and Edmund Baker analyze the synonymy of certain of the species and call rather emphatic attention to the desirability of consulting types in serious systematic work. Some slight bibliographic confusion is likely to result from the publication of Mr. Ashe's paper in separate form long enough before the number of the *Journal* containing it was issued to enable him to revise the latter into quite a different article. T.

Combs's Flora of Santa Clara Province, Cuba. — The island of Cuba is one of considerable interest to the botanist, as is shown by the rich collections made by many early explorers. In recent years, however, the region seems to have been neglected. We have before us a contribution of considerable length devoted to the flora of Cienfuegos, province of Santa Clara, by Robert Combs.[1] The author enumerates 713 species, of which *Caesalpinia cubensis*, *Acacia*

[1] Plants Collected in the District of Cienfuegos, Province of Santa Clara, Cuba, in 1895–1896. *Trans. Acad. Sci. of St. Louis*, 7: 393–491, pls. 30–39, one map, 1897. (Contributions Botanical Department, Iowa State College of Agric. and Mechanic Arts, No. 7.)

polypyrigenes, *Rondeletia combsii*, *Catesbaea nana*, *Anastraphia northropiana*, *Tabebuia petrophila*, and *Chloris eleusinoides*, var. *vestita*, are new. In addition to the enumeration of the species, full notes on the abundance and character of the soil on which the plants occurred are given. Œcologically, the flora may be divided into seven regions: (1) the maritime, (2) the river bottoms, (3) inland swamps or "cienegas," (4) upland woods, (5) the mountain regions, (6) the savannahs or wooded grass lands, and (7) a kind of arid, desert-like region. Each region has many typical plants. These regions, however, grade into each other; some plants occur in one or more regions. The orders Leguminosæ, Compositæ, Rubiaceæ, Euphorbiaceæ, Malvaceæ, and Gramineæ lead in point of numbers, and it is probable that the Gramineæ and Cyperaceæ are more numerous than given in the catalogue, and that the number could be considerably augmented by another season's collecting. It is to be hoped that Mr. Combs may again visit this region. The catalogue is, however, a representative one, since the collecting was done during both the dry and the wet season, the dry season, when Compositæ are most abundant, corresponding to our winter. The determinations were made by J. M. Greenman, of Cambridge, who is well qualified to speak on the Cuban flora, having previously studied the Northrop collection. The paper contains the vernacular Spanish names, and these are quite numerous because of the many uses that Cubans make of the native plants for medicinal purposes. Mr. Combs has further given a short account of Cuban medical plants in another paper.[1]

L. H. PAMMEL.

Central American Botany. — Captain J. Donnell Smith, who for a number of years has been concentrating his energy on the Central American flora, publishes his twentieth installment of descriptions of new plants from Guatemala and other Central American republics in the *Botanical Gazette* for March. One new genus, Prosthecidiscus, of the Asclepiadaceæ, is characterized and well figured.

Epiphyllous Flowers. — The knowledge of this unusual type of inflorescence, summarized by C. de Candolle[2] and Gravis[3] a few years since, is enriched by a study of *Chirita hamosa* conducted under the direction of Professor Warming, of the Copenhagen Uni-

[1] Some Cuban Medical Plants. *Pharmaceutical Review*, **15**: 87–91, 109–112, 136, 1897.

[2] *Mém. Soc. de Phys. et d'Hist. Nat. de Genève*, 1890, suppl. vol.

[3] *Comptes Rend. Soc. Roy. de Bot. de Belg.*, 1891.

versity, by C. E. Boldt, the results of which appear in the *Videnskabelige Meddelelser* for 1897 of the Natural History Society of that city.

Forest Trees. — Professor Büsgen, of the Eisenach Forestry School, has recently published a handbook of information concerning the structure and life processes of forest trees,[1] which are considered as to their winter aspect, the causes of their forms, buds, tissues, wood and bark structure, annual or growth rings, formation of heart wood, leaves, root activity, uses and source of water and mineral matters, metabolism and the transportation of food, fructification and germination. The illustrations, many of which are original, contribute materially to the elucidation of the subjects discussed. T.

The Work of Aldrovandus. — In December last the city of Bologna celebrated the opening of a hall commemorative of one of her first botanists, and the proceedings on that occasion, accompanied by an analysis of his works, form an attractive octavo pamphlet[2] which has recently been published.

Botanical Notes. — The volume of *Transactions of the Kansas Academy of Science* for 1895–96, issued in the early part of the present year, contains the following papers on botany: "Additions to the Grasses of Kansas," by A. S. Hitchcock; "Additions to the Flora of Kansas," by B. B. Smyth; "The Propagation of Erythroniums," by E. B. Knerr; and "A Provisional List of the Flowering Plants of McPherson County," by H. J. Harnly.

Dr. B. L. Robinson brings together, in the *Botanical Gazette* for March, notes extending the range of several North American species of Caryophyllaceæ which have come to his notice since the publication of the last fascicle of the *Synoptical Flora*, and adds to the flora two new species (*Stellaria oxyphylla* and *S. washingtoniana*, both from the Northwest), and two (*Arenaria uliginosa* and *Drymaria cordata*) previously described from without our range.

Under the title of "Contributions to Western Botany, No. 8" — unfortunately without evident indication of place of publication —

[1] Büsgen, M. *Bau und Leben unserer Waldbäume.* Jena, Fischer, 1897. 8vo, viii + 230 pp., 100 ills.

[2] Mattirolo, O. *L'Opera botanica di Ulisse Aldrovandi* (1549–1605). Bologna, Fratelli Merlani, 1897. 8vo, xxx + 137 pp., with portrait.

Professor Marcus E. Jones, of Salt Lake City, Utah, has issued a pamphlet of some forty-five pages octavo, in which a considerable number of species of plants are described as new to science. Having had the good fortune, as he states, to see nearly all the types of North American Astragali during the past year, Mr. Jones has not a little to say about this much-vexed genus. A round-topped Composite shrub from the Panamint Mountains of California is made the type of a new genus, close to Dysodia, under the name *Inyonia dysodioides*.

No. 7 of Professor Greene's "Studies in the Compositæ," published in part in the signatures of *Pittonia* issued Feb. 25, 1898, contains a rearrangement of the Composite genus Actinella, which, since the name is held to be invalid because it was early used in a different sense, is renamed Tetraneuris as to most of its species, and Rydbergia as to *Actinella grandiflora* Gray and its variety *glabra*. Eight species are described as new.

The *Bulletin of the Torrey Botanical Club* for March contains a paper by Professor Greene on "New Compositæ from New Mexico," in which seventeen species or varieties and one genus, Wootoria, are described as new.

The Pacific Coast Valerianellas, under the generic names Plectritis and Aligera, form the subject of a brief synopsis by Mr. Suksdorf in *Eythea* for March. One additional species, *Aligera Jepsonii*, is described.

Dr. Small contributes a thirteenth part of his studies in the botany of the Southern United States to the *Bulletin of the Torrey Botanical Club* for March. Twenty-four species and one genus, Forcipella, pertaining to the Paronychiaceæ, are described as new.

Crépin's section Minutifoliæ, of the genus Rosa, receives a second species in *Rosa stellata*, of the New Mexican region, described and figured by Professor Wooton in the *Bulletin of the Torrey Botanical Club* for March.

Lilæa, a monotypic monocotyledonous genus widely distributed through the western part of the American continent, and concerning the systematic position of which there is diversity of opinion, has been studied by Professor Campbell, whose paper, published in the *Annals of Botany* for March, leads to the conclusion that while there is not much evidence of the direct derivation of this simple type from the Pteridoplytes, there is likewise no evidence that it represents a

degraded form, the author's belief being that the simplicity of its flowers is really primitive.

In a paper in the *Videnskabelige Meddelelser* of the Copenhagen Natural History Society for 1897, Dr. V. A. Poulsen, whose work in this field extends over many years, publishes a paper dealing with the extrafloral nectaries of Excœcaria, Fragræa, Vaccinium, and Shorea.

Professor Hitchcock, who is giving more time to œcological studies than most Experiment Station botanists appear to find time for, publishes as *Bulletin No. 76* of the Kansas Station at Manhattan a well-illustrated paper on "The Vegetative Propagation of Perennial Weeds."

Professor Pammel, whose work on the seedcoats of Leguminosæ and Euphorbia is well known, issues as contribution No. 6 from the Botanical Department of the Iowa State College a paper on the seeds and testa of some Cruciferæ, reprinted from the *American Monthly Microscopical Journal.* The paper is freely illustrated by figures showing the macroscopic appearance and microscopic structure of the seeds studied.

Dr. F. Höck, Oberlehrer in Luckenwalde, has recently published a concise elementary treatise on botanical geography.[1]

Under the title "A First Ohio Weed Manual,"[2] Professor A. D. Selby publishes an instructive discussion of the weed question in general and a descriptive illustrated list of Ohio weeds.

Lathyrus splendens, a beautiful species of Southern California, is figured in the *Gardeners' Magazine* for February 12.

Vanilla is considered with respect to its botany, cultivation, microscopy and chemistry in the *Journal of Pharmacy of New York* for February.

The principal weeping willows form the subject of an instructive article by A. Rehder in *Moeller's Deutsche Gärtner-Zeitung* for February 19, in which good figures are published of *Salix elegantissima*, *S. alba vitellina pendula*, *S. blanda*, and *S. salomoni.*

[1] Höck, F. *Grundzüge der Pflanzengeographie.* Unter Rücksichtnahme auf den Unterricht an höheren Lehranstalten. Breslau, Ferdinand Hirt, 1897. 190 pp., 50 ills., 2 maps.

[2] Ohio Agricultural Experiment Station, *Bulletin No. 83.* Wooster, Ohio, September, 1897. 8vo, 249–400 pp., 71 ills.

The rupestris section of Selaginella, as represented in the United States, forms the subject of a paper by Professor Underwood in the *Bulletin of the Torrey Botanical Club* for March, in which six species and one variety are described as new, and two previously described forms are resurrected as of specific rank.

Prof. E. A. Burt publishes in the *Botanical Gazette* for March a useful paper on collecting and preparing fleshy fungi for the herbarium.

In the fourth Heft of the current volume of Engler's *Botanische Jahrbücher*, Professor Engler brings to a conclusion his series of "Beiträge zur Flora von Africa." The contributors to this concluding paper are Engler, Hoffmann, and Kränzlin.

Professor Spegazzini, in the *Revista* of the La Plata agricultural and veterinary Faculty for August and September last, publishes an annotated list of something over two hundred species of Patagonian plants, several of which are described as new, under the title "Primitiæ floræ Chubutensis."

A novel local flora is the *Flora urbica pavese*, published by Traverso in the *Nuovo Giornale Botanico Italiano* for January, and enumerating an even century of flowering plants and ferns which grow spontaneously in the city of Pavia.

The third *Bulletin of the New York Botanical Garden* contains an interesting series of reports on the organization and administration of the establishment, a surprisingly long list of plants cultivated in 1897, and descriptions and illustrations of the proposed plant houses and museum building. The sites of the garden and the proposed zoological park are indicated on a simple outline map of Bronx Park.

Under the title of *The Cactus Journal*, a new monthly, devoted exclusively to cacti and other succulent plants, largely from the point of view of the cultivation of such plants, has been started in London. The first number, for February, 1898, is illustrated by two well-executed gelatine prints, from photographs, illustrating a number of interesting cacti.

From a study of the paper of a Hebrew document from the synagogue of Old Cairo, Mr. Dawson concludes that as far back as the year 1038, — the date assigned to the manuscript, — the process of manufacturing paper from the fibers of the flax plant was both known and employed.[1]

[1] *Annals of Botany*, **12**: 111–115, March, 1898.

GEOLOGY.

A New Edition of Dana's Geology. — Dana's *Revised Text-Book of Geology*[1] has recently appeared in a dress that is much more attractive than that so familiar in earlier editions. Professor Dana had begun a revision of the work a short time before his death. The completion of the revision has been undertaken by Prof. W. N. Rice, of Wesleyan, and with great success. The distinctive characteristics of earlier editions have been retained in the new edition, but the volume has been modernized by the replacement of the old zoological and botanical classifications by those adopted in recent manuals, by a fuller recognition of the theory of evolution as a working hypothesis in paleontology, and by a modification of earlier statements concerning metamorphism. The ending *yte* for rock names has also been abandoned for the more usual *ite.*

In his preface to the new edition the editor declares that he undertook the revision with the understanding that the book "was to be brought down to the present time as regards its facts, but it was still to express the well-known opinions of its author." That he was the right man for the delicate task of "editing" this, the most popular of Dana's works, is abundantly proven by the excellence of the new book. It still presents all of its author's well-known views on debatable questions, and yet is, in the main, a splendid compendium of the truths of geology as now accepted by conservative students of the science.

In one or two points only can ultra conservatism be charged. The Archean remains undivided, no distinction having been made between the typical clastic pre-Cambrian rocks and the series of crystalline schists that lie unconformably beneath these, — a distinction that is now made by nearly every geologist who has worked in undoubted pre-Cambrian regions.

With respect to the treatment of the topic metamorphism the same fault may be found. The editor leaves the impression on the reader's mind that nearly all the gneisses, mica-schists, etc., are recrystallized sedimentary rocks, though, it is true, he declares that in some cases they may be produced from plutonic rocks. He also suggests that granite itself may be of metamorphic origin, in spite of the fact that no specialist in the study of rocks has ever

[1] Dana, James D. *Revised Text-Book of Geology.* Fifth edition. Revised and enlarged. Edited by William North Rice. American Book Company, 1897. ix + 482 pp., 464 ills.

discovered any evidence that this is the case. Unfortunately the distinction between bedding and schistosity is not made clear. The secondary structure, by inference at any rate, is made coincident with the primary one, for we read that "the presence of a schistose structure is not always proof of origin from sediments."

Of course Professor Rice had a very difficult position to fill. He has filled it well, and yet we wish for the sake of the students who will use the revised text-book that he had departed a trifle more from Professor Dana's views, and incorporated in the book the latest results of investigations upon the oldest rocks of the globe and on metamorphism.

W. S. B.

MINERALOGY.

The Fourth Edition of Fuchs's Determinative Mineralogy.[1]— Although the *Anleitung zum Bestimmen der Mineralien*, by Prof. Dr. C. W. C. Fuchs, was first published thirty years ago, and has since been revised by Professors Streng and Brauns, the well-known volume still preserves its original excellent features. The third edition was published only eight years ago. Since this time there has been so much added to our knowledge of minerals that a fourth edition has been demanded. Dr. Brauns, who is responsible for the new edition, is eminently fitted for the work that has devolved upon him, and the new volume that has been brought out under his direction is fully abreast of the times.

There has been little change made in the sections treating of blowpipe and microchemical reactions except such as are necessitated by the progress of knowledge during the past decade. The tables for the determination of minerals, however, have been entirely reconstructed. The minerals are no longer separated into groups according to their crystal systems, but are divided according to hardness. These groups are further divided into two classes, *viz.*, minerals with metallic luster and those without metallic luster. The metallic minerals are next subdivided according to color, and the non-metallic ones according to the color of their streak. The cleavage, crystal form, and manner of occurrence serve further as distinguishing characteristics, and simple chemical tests are made use of for pur-

[1] Fuchs, C. W. C. *Anleitung zum Bestimmen der Mineralien.* Vierte Auflage, neu bearbeitet, von Dr. Reinhard Brauns. Giessen, J. Ricker, 1898. xii + 235 pp.

poses of final identification. As far as possible only those chemical reactions are described that are necessary to identify the minerals, and these are always simple ones.

The book is too well known to all mineralogists to require further characterization. It is sufficient praise to state that the fourth edition is an advance over all the editions that have preceded it.

W. S. B.

Hardness of Minerals. — Jaggar has described[1] a new instrument for the determination of the hardness of minerals. After briefly summarizing the results of previous workers on this subject, he describes the chief sources of error in their methods as follows: "(1) personal variability due to using 'visibility' of a scratch as determinant; (2) inequalities of surface; (3) undefined details of instrument. To eliminate (1) the depth of abrasion should be definite and measurable; to eliminate (2) the surface should be artificial and defined, and the boring method, where only a very small portion of the surface is initially touched, should be used; to eliminate (3) every part of the instrument, including the abrader, should be minutely defined, and for comparative determination an empirical standard should be fixed."

The instrument devised to overcome these difficulties and to meet the other conditions of the problem presented is intended to be applied to the microscope in order that the measurements may be made either on a crystal face or the surface of a thin section, that the test may be applied to very small portions of mineral, and that the control of the instrument may be very exact. "The principle of the instrument is as follows: a diamond point of known, constant dimensions is rotated on an oriented mineral surface, under uniform rate of rotation and uniform weight, to a uniform depth. The number of rotations of the point, a measure of the duration of the abrasion, varies as the resistance of the mineral to abrasion by diamond; this is the property measured. The instrument consists of the following parts:

(1) A standard and apparatus for adjusting to microscope with various adjustments.

(2) A balance beam and its yoke.

(3) A rotary diamond in the end of the beam.

(4) Apparatus for rotating uniformly.

[1] Jaggar, T. A., Jr. A Microsclerometer for Determining the Hardness of Minerals. *Am. Jour. of Sci.*, vol. iv, pp. 400–412, 1897.

Also *Zeit. f. Krystall.*, vol. xxix, pp. 262–275, 1898.

(5) Apparatus for recording rotations.
(6) Apparatus for locking and releasing beam.
(7) Apparatus for recording depth.

After giving detailed descriptions of the various parts of the instrument and the method of use and calibration, the results are given of a preliminary series of tests on the minerals of the Mohs scale of hardness, and the following table shows the values obtained, together with those of two other investigators for comparison:

	Pfaff, 1884.	Rosiwal, 1892.	Jaggar, 1897.
9. Corundum	1000	1000	1000
8. Topaz	459	138	152
7. Quartz	254	149	40
6. Orthoclase	191	28.7	25
5. Apatite	53.5	6.20	1.23
4. Fluorite	37.3	4.70	.75
3. Calcite	15.3	2.68	.26
2. Gypsum	12.03	.34	.04

The possibility is suggested of using the instrument for other ends than the determination of hardness; the extreme exactness of the appliance for measuring the vertical movement of the diamond point makes it possible to determine the thickness of a mineral section, and of the thickness of a mineral necessary to produce in polarized light a given interference color, whence the double refraction may be calculated. The borings from very minute crystals in thin section might also be subjected to chemical tests, — a novel method of isolation.

Tables of Crystal Angles. — Goldschmidt, continuing his valuable work on the use of the goniometer with two circles, has published a table[1] of angles for the forms of all crystallized minerals. The construction of such a table is first made possible by the new method of measurement of crystals involved in this goniometer. In the old method of measurement of interfacial angles, such a table involved the presentation of the angles which each form makes with every other, and the number of values would be so great that its very bulk would render it impracticable or even useless. Monographs on individual mineral species contain approximations to such complete tables of angles, but these were widely scattered through the literature. But with the two-circle goniometer, each face is determined independently, once the crystal is oriented on the instrument, by the measurement of two angles which suffice, the crystallographic ele-

[1] Goldschmidt, V. *Krystallographische Winkeltabellen.* Berlin, J. Springer, 1897.

ments being known, for the complete characterization of the form. Thus the table of angles is vastly simplified, and reference to it for any newly measured form is easy.

The present table contains, besides these two characteristic angles, ϕ and ρ, for each form, several supplementary angles which facilitate the comparison of measurements made by the two methods, and also several linear values of use in plotting the gnomonic projection of the forms.

An introduction contains necessary explanations of the values given in the tables and the schemes employed for each system for calculating the various values from the elements and symbol of the form. The total number of values tabulated is something over 70,000, of which nearly one-half required separate calculation, the remainder being such fixed values as 60 or 45 degrees. A summary of the number of minerals crystallizing in each system and of their forms is interesting. There are in

Isometric	System,	102	minerals	with	719	simple	forms.
Tetragonal	"	47	"	"	589	"	"
Hexagonal	"	91	"	"	1457	"	"
Orthorhombic	"	170	"	"	2783	"	"
Monoclinic	"	122	"	"	2157	"	"
Triclinic	"	21	"	"	404	"	"
Total		553	"	"	8109	"	"

The publication of these tables removes one of the frequently urged objections to Goldschmidt's instrument and method of calculation, — that it had no connection with the great mass of observations hitherto made and gave results which could not be directly used and compared with those of other observers. The contrary is now true, for this work brings together in simple form an enormous mass of results previously not nearly so accessible. It is a logical conclusion to the elegant system of crystal measurement and discussion which the author has developed and should do much to extend the use of his time and labor-saving methods among students of crystallography.

Catalogue of Minerals. — Chester[1] has published a new edition, revised to date, of his list of minerals. It gives all the names in common use, stating of each whether it be a species or variety name, or a synonym. The approximate chemical composition is given after each species. The list serves as a convenient check-list, its alphabetical arrangement increasing its usefulness in this way.

[1] Chester, A. H. *A Catalogue of Minerals.* New York, J. Wiley & Sons, 1897.

SCIENTIFIC NEWS.

THIS is the jubilee year of Professor W. K. Brooks, and it seemed, therefore, to his pupils, past and present, an appropriate time to make some especial demonstration of the affection and esteem in which he is held by all of them, who include many of the leading zoologists of this country. Accordingly a committee, consisting of Professors H. H. Donaldson, W. H. Howell, E. A. Andrews, E. B. Wilson, H. V. Wilson, S. Watasé, and T. H. Morgan, was appointed and arrangements were made to present him with a portrait. His birthday, March 25, was the date chosen for the presentation, which was made by Professor Howell in the presence of twenty-two of the subscribers assembled at Brightside, Professor Brooks's home near Baltimore. The portrait, which was painted by Mr. Thomas C. Corner, is a very good likeness and represents Dr. Brooks seated with an open book in an attitude that is very characteristic and will call to mind many an interesting hour in the little "seminary room" of the Biological Laboratory at Johns Hopkins.

The Reception Committee of the Fourth International Congress of Zoology has issued a circular containing particulars with regard to lodgings and other accommodation at Cambridge during the meeting in August next, and giving other information as to the railway fares from various parts of the Continent, and other arrangements for the Congress. The circular is accompanied by a reply-form, to be filled out and returned to the Secretaries by any member of the Congress who wishes rooms to be taken for him. These circulars have been sent to all who have already informed the Reception Committee that they hope to be present at the meeting, and will be sent to other zoologists who apply to the Secretaries of the Reception Committee, The Museums, Cambridge, England.

At the meeting of the Council of the Boston Society of Natural History, April 20, it was unanimously voted to award the Grand Honorary Walker Prize of $1000 to Mr. Samuel Hubbard Scudder, of Cambridge, for his contributions to entomology, fossil and recent. The Walker prizes in natural history were established in 1864 and, in addition to the annual awards for memoirs on subjects proposed by a committee, provide for a Grand Honorary Prize to be given

not oftener than once in five years. The provisions of Dr. Walker's foundation allow the Council to pay "the sum of $500 for such scientific investigation or discovery in natural history as they may think deserving thereof, provided such investigation or discovery shall have first been made known and published in the United States of America, and shall have been at the time of said award made known and published at least one year; if, in consequence of the extraordinary merit of any such investigation or discovery, the Council of the Society shall see fit, they may award therefor the sum of $1000." The Grand Honorary Walker Prize was first awarded in 1873 to Dr. Alexander Agassiz for his investigations in the embryology, geographical distribution, and natural history of the echinoderms. Since this first award in 1873, the Grand Honorary Walker Prize has been given to Professors Joseph Leidy, James Hall, and James D. Dana. In all cases the maximum amount, $1000, has been given.

Papers read at the April meeting, 1898, of the National Academy of Sciences: The Coral Reefs of Fiji, A. Agassiz. The Fiji Bololo, A. Agassiz and W. McM. Woodworth. The Acalephs of Fiji, A. Agassiz and A. G. Mayer. The Variation in Virulence of the Colon Bacillus, J. S. Billings. Biographical Memoir of Edward D. Cope, Theodore Gill. New Classification of Nautiloidea, Alpheus Hyatt. A New Spectroscope, A. A. Michelson. On the Hydrolysis of Acid Amides, Ira Remsen and E. E. Reid. The Question of the Existence of Active Oxygen, Ira Remsen and W. A. Jones. On the Product formed by the Action of Benzenesulphonchloride on Urea, Ira Remsen and J. W. Lawson. On Double Halides containing Organic Bases, Ira Remsen. McCrady's Gymnophthalmata of Charleston Harbor, W. K. Brooks. Ballistic Galvanometry with a Countertwisted Torsion System, Carl Barus. A Consideration of the Conditions governing Apparatus for Astronomical Photography, Charles S. Hastings. The Use of Graphic Methods in Questions of Disputed Authorship, with an Application to the Shakespeare-Bacon Controversy, T. C. Mendenhall. A Method for obtaining a Photographic Record of Absorption Spectra, A. W. Wright. Theories of Latitude Variation, H. J. Benedict, introduced by A. Hall. Progress in the New Theory of the Moon's Motion, E. W. Brown, introduced by S. Newcomb. On the Variation of Latitude and the Aberration-Constant, Charles L. Doolittle, introduced by S. S. Chandler. A Curious Inversion in the Wave Mechanism of the Electromagnetic Theory of Light, Carl Barus.

The first of what promises to be a helpful series of guides in nature study has recently been issued by Mr. G. W. Carver, of the Normal and Industrial Institute at Tuskegee, Alabama, and, although it consists of only twelve small pages and costs but five cents, it is full of suggestions useful alike to teacher and pupil.

The concluding numbers of vol. vii of the *Journal of Comparative Neurology* (March, 1898) contain the editorial announcement that with the next volume the efficiency of the journal will be greatly increased by the addition of a number of new collaborators, among whom are Dr. Adolf Meyer, Dr. B. F. Kingsbury, Prof. G. C. Huber, and Prof. Ludwig Edinger. The present numbers include, beside the usual literary notices, an article by the chief editor on Psychological Corollaries of Modern Neurological Discoveries, Inquiries Regarding Current Tendencies in Neurological Nomenclature, by C. L. and C. J. Herrick, and a lengthy contribution on the Motor Nerve-Endings and on the Nerve-Endings in the Muscle-Spindles, by G. C. Huber and L. M. A. De Witt.

The Psychological Index, No. 4, published under the auspices of *The Psychological Review*, contains a bibliography of the Literature of Psychology and Cognate Subjects for 1897. The 2465 titles are arranged in convenient subdivisions under eight general divisions, and the list is concluded with an excellent authors' index. The Index aims at completeness, for which it begs the coöperation of authors and publishers.

The city of Geneva, Switzerland, has received the estate of Sécheron and 300,000 francs by the will of Philippe Plantamour, and will probably convert the estate into a botanic garden, thus supplementing the present garden behind the university.

The bill passed by the legislature of Maryland appropriating $50,000 for two years for the Johns Hopkins University has but two faults. It appropriates too little, and the appropriation is made for too short a time. There is nothing which has proved such a credit to the state of Maryland as this university, and its present serious financial condition is due to the depreciation of securities which it bought from the state.

Cornell University will maintain a summer school of botany this year from July 5 to August 15.

Professor A. E. Verrill, of Yale, has gone to the Bermudas with a party of students.

The Ornithological Union of Vienna has disappeared as a distinct organization, and now forms a section of the Royal-Imperial Zoological-Botanical Society. The quarterly journal of the union, *Die Schwalbe*, is discontinued after twenty-four volumes.

The Museum of Natural History of Paris has recently acquired the Ragonot collection of Microlepidoptera and the Berthelin collection of fossil Foraminifera.

We learn from *Natural Science* that a natural history museum is being established in the Vatican, geological and mineralogical collections being already displayed.

Bradney B. Griffin, a fellow of Columbia University, died in New York, March 26, aged 26. He was a promising zoologist, and had published articles upon the invertebrate fauna of Puget Sound and upon the fertilization of Thalassema. A larger paper on this same subject was in the printer's hands at the time of his death.

The United States National Museum has received a second specimen of the fish *Acrotus willoughbyi*, of the family Stromateidæ. Like the type and only known specimen, it comes from Washington, and will probably supplement the information derived from the former incomplete specimen. The type was described as having the bones of the head so weak that a pull of about five pounds would pull off the head. This second specimen is stated to have the head mutilated.

Mrs. Phœbe Hearst has given a building for the School of Mines to the University of California. The building will be fully equipped at her expense.

The Belgian Academy of Science offers prizes of $120 for the best articles upon the following subjects: Digestion in Carnivorous Plants; Development of a Platode, and its bearings upon the question of the relations of Platodes to Enterocœles; Do the Schizophytes possess a nucleus? and if so, what is its nature and how does it divide? The competition is open to all.

Jules Marcou died in Cambridge, Mass., April 17. He was born in Salins, department of the Jura, April 20, 1824, studied geology, and in 1847 was appointed to the paleontological staff of the Sorbonne. In 1848 he came to the United States, where he worked in connection with Agassiz. 1851 and 1852 he spent in Europe, and in 1855 he received the appointment of professor of geology in the University of Zürich. In 1860 he returned again to the United

States, which became his home until his death, although he made several longer or shorter visits to Europe. He published several books and many shorter papers upon the geology of the United States.

Sir William Turner, professor of anatomy in the University of Edinburg, has been elected corresponding member of the Academy of Sciences of Berlin.

Lawrence Bruner, state entomologist, and professor of entomology in the University of Nebraska, has returned from his year spent in the Argentine Republic, where he has been studying the locust plague.

The University of Nebraska will maintain a summer school this summer, offering eighteen courses, among them botany, zoology, entomology, and geology. The session will extend from June 6 to July 16.

Mr. E. H. Lonsdale died March 7 at Columbia, Mo. From an obituary sketch by Dr. C. R. Keyes in the *American Geologist*, we learn that Mr. Lonsdale was born in 1868, educated at the University of Missouri. He was connected at two different times with the geological survey of his native state and with the geological survey of Iowa. At the time of his death he was a member of the staff of the United States Geological Survey. He published several papers of the Geology of Missouri and Iowa, and at the time of his death was at work at a large report on the clays of the latter state.

The University of Chicago has made the following appointments to fellowships: Anthropology, A. W. Dunn; Geology, C. E. Siebenthal, W. N. Logan, J. W. Finch, R. George; Zoology, H. H. Newmann, H. E. Davis, R. S. Lillie, M. F. Guyer, Emily R. Gregory; Neurology, I. Hardsty; Archæology, Caroline L. Ransom; Botany, W. R. Smith.

Prof. David S. Kellicott, of the University of Ohio, died at his home in Columbus, April 13, aged about 48 years. For several years he was engaged in teaching Natural History in the State Normal School at Buffalo, N. Y., and while there he held various offices in the Buffalo Society of Natural Science. In 1888 he was called to the chair of zoology in the Ohio State University as successor to Albert H. Tuttle. His work was largely in the lines of the Protozoa, fresh-water sponges, and the Odonata, of which he described many new forms. He had been elected General Secretary of the American Association for the Advancement of Science to serve at the fiftieth anniversary meeting this year in Boston.

Prof. W. Pfeffer, of Leipzig, delivered the Croonian Lecture before the Royal Society, March 17, upon the nature and significance of functional metabolism in the plant.

The legislature of Massachusetts has granted $200,000 this year to aid in the hopeless task of trying to exterminate the gypsy moth.

Recent appointments: Dr. Charles R. Barnes, of the University of Wisconsin, professor of vegetable physiology in the University of Chicago. — Dr. W. B. Benham, of the University of Oxford, goes to the University of Otago, Dunedin, New Zealand, as successor to the late Professor Parker. — A. L. Bolk, professor of anatomy in the University of Amsterdam. — G. Born, professor of anatomy in the University of Breslau. — G. C. Bourne, lecturer on comparative anatomy in the University of Oxford. — Prof. Carl Chun, of Breslau, professor of zoology in the University of Leipzig, as successor to Leuckart. — H. T. Fernald, professor of zoology in State College, Pennsylvania, economic zoologist of Pennsylvania. — B. E. Fernow, chief of the Division of Forestry in the United States Department of Agriculture, director of the school of forestry in Cornell University. — Baron von Firks, assistant in geology in the mining school at Freiburg, Saxony. — Dr. Sigmund Fuchs, professor extraordinarius of physiology in the University of Vienna. — Henry Hanna, demonstrator of biology, geology, and paleontology in the Royal School of Science, Dublin. — Harold Heath, assistant professor of zoology in Leland Stanford University. — Dr. P. Malera, professor of physiological chemistry in the University of Naples. — Prof. F. Morini, professor of botany at Bologna. — H. W. Pearson, assistant curator of the herbarium of the University of Cambridge. — Cornelius L. Shear, of the University of Nebraska, assistant agrostologist in the United States Department of Agriculture. — H. W. M. Tims, professor of zoology in Bedford College, Bedford, England. — Dr. Warburg, professor of botany in the University of Berlin.

Recent deaths: N. Alboff, Russian botanist, at La Plata. — Dr. Delmas, geologist, at Custries, France. — Rev. William Houghton, ichthyologist, at Wellington, England. — Professor Kirk, of New Zealand, author of important works on the flora and forestry in the colony. — Alfred Monod, cryptogamic botanist, aged 61. — F. W. Seydler, botanist, at Braunsberg, aged 80. — James Thompson, student of Coleoptera. — Dr. T. C. Winkler, curator of the Teyler museum at Haarlem, well known as a student of fossil vertebrates.

CORRESPONDENCE.

Birds of the Galapagos Archipelago.[1]

Editor *American Naturalist.*

Sir: — The September number of the *American Naturalist* contains a criticism of my "Birds of the Galapagos Archipelago" which I have not answered sooner from want of time. I would gladly pass it by were it not that certain erroneous quotations and important misconstructions contained in Dr. Baur's "criticism" should not be allowed to stand uncorrected.

Regarding a certain missing box of specimens from the southern part of Albemarle Island, Charles Island, etc., Dr. Baur says: "I shall now make a few remarks about the birds from Charles, Hood, Barrington, and South Albemarle, which were contained in a box which disappeared in Guayaquil. The loss is not quite so unfortunate as stated by Mr. Ridgway. He remarks that it contained more than forty land birds from the southern part of Albemarle Island, but this statement, as will be seen from the list which I now give, is not correct."

In a letter (now in my possession) dated Oct. 12, 1891, Dr. Baur wrote me: "That *Creagrus* is a very common bird you probably have heard already from Mr. Adams; also, that we got *over forty species of birds from S. Albemarle.*" In another dated March 1, 1892, he wrote: "One box containing other *small birds* has unfortunately been lost on the way, probably at Panama, and so far no trace of it has been found"; while in still another, dated April 29, 1894, he says: "It is a great loss that one box with small birds was stolen at Guayaquil. I see now that it contained the specimens from Charles, Hood, Barrington, and South Albemarle."

Since Dr. Baur distinctly wrote me, as quoted above, that he and Mr. Adams collected more than forty species of birds on South Albemarle, and later twice informed me they were *small* birds, it will be seen that I was justified, from the knowledge in my posses-

[1] With Mr. Ridgway's kind consent, his letter written Nov. 19, 1897, has been withheld from publication on account of the unfortunate illness of Dr. Baur, which prevented us from submitting the letter to him for comment or reply. Dr. Baur, being in Europe at present, is still ignorant of this letter, but it does not seem wise or fair to Mr. Ridgway to delay its publication any longer. — Editor.

sion at the time, in the statement which I made concerning the box in question.

With further reference to the birds of South Albemarle, Dr. Baur makes the following singular statement: "Ridgway enumerates thirty-five species from Albemarle, and remarks: 'As Dr. Baur and his associate, Mr. Adams, collected more than forty species in South Albemarle, there are at least twenty-five species found there which are as yet undetermined.' I cannot support this statement. Ridgway himself names thirty-three species collected by us." Concerning this I have only to say that reference to pages 469 and 470 of my paper will show that it is wholly unwarranted. The list of thirty-five species, thirty-three of them collected by Baur and Adams, given by me on page 469, is plainly not a list of birds of *South* Albemarle but of Albemarle Island *as a whole*. On page 470 of my paper are separate lists for "East Albemarle, opposite Cowley Island" and "South Albemarle," both copied from lists furnished me by Dr. Baur, the originals of which I still possess. The South Albemarle birds, as enumerated by Dr. Baur, number sixteen species. Having no reason to doubt Dr. Baur's statement that he and Mr. Adams "got over forty species of birds from S. Albemarle," and since "over forty species" would necessarily be equivalent to at least forty-one, and since sixteen subtracted from forty-one would leave "at least twenty-five species" to be accounted for, it would appear that my statement was strictly in accordance with the facts as known to me. Dr. Baur has named nine of the species which were unknown to me; therefore, there should be still "at least" sixteen unidentified species of South Albemarle birds. Not one of these nine additional species was included in the two lists of Albemarle birds which Dr. Baur sent me, nor were they contained in the collection which he sent for my examination. There is good reason, therefore, why they were omitted from my list.

It is difficult to understand why Dr. Baur should have criticised my remarks concerning the large white heron from Albemarle, given in my paper as doubtfully *Herodias egretta*, but which Dr. Baur is positive is that species. The doubts which I expressed as to the bird being that species were based upon Dr. Baur's description of its size ("as large as, perhaps larger than, *A. herodias*"), which certainly cannot apply to *H. egretta*. The latter is conspicuously *smaller* than *A. herodias* (only about one-third its bulk[1]). There-

[1] Audubon gives the weight of *H. egretta* as two and a half pounds; *A. herodias* often weighs as much as seven pounds.

fore, it necessarily follows that either Dr. Baur's statement of the size of the bird which he saw but did not obtain is very incorrect, or else that my doubt as to its being *H. egretta* was very well founded. It would be interesting to know by what process Dr. Baur was able, under the circumstances, to positively identify the species.

In the "Additions to the List of Birds given by Ridgway for the Different Islands" (pages 782–84), I have found it difficult to find out exactly what Dr. Baur means to show; but in my attempt to do so have made one important discovery, which is that the species named, which are really additional to the lists given in my paper for the separate islands, were certainly not among the specimens which Dr. Baur sent me for examination, and therefore I cannot be responsible for the omissions. Many of the species which he names do occur in my lists, however, but in the case of most of these, *owing to the circumstance that no Baur-Adams specimens were known to me*, the "x" was not entered in the column for that collection. The importance of the portion of the collection which was not sent to me may be realized from the fact that, according to Dr. Baur's paper, his collection contained specimens of *Camarhynchus pallidus* ("*Cactornis pallida*") from Duncan, Chatham, and Jervis Islands, while he sent me only two specimens, one from Jervis, the other from James Island. Neither did I see a specimen of *Nesomimus macdonaldi* from Gardner Island; had I been able to do so, it is hardly necessary for me to say that the mistake respecting the identification of this bird to which Dr. Baur refers (see footnote on page 783) would not have occurred.

The remaining point upon which Dr. Baur's criticisms bear is the first one mentioned by him, and the one to which he devotes most space; but I prefer to consider it last and most briefly, since it is chiefly a matter of opinion, while the others are questions of fact. What are genera and what are not is, in many cases, very difficult to determine. To Dr. Baur *Cactornis* and *Geospiza* seem to be distinct, and to have them so would better fit his theory of distribution. To me they are not distinct, because it is impossible to draw any line between them.[1] It is, of course, disappointing to find sometimes that facts do not entirely support our theories; but it seems to me

[1] I would here call attention to Dr. Baur's erroneous quotation of my remarks on page 778, where, in the eighth line from the bottom, the following should be inserted after the first word: "I am still of the opinion that not a single character can be found."

both unscientific and unsafe to draw artificial lines of demarcation in such cases, even when Nature's neglect to do so causes serious inconvenience.

ROBERT RIDGWAY.

SMITHSONIAN INSTITUTION, WASHINGTON, D. C.,
November 19, 1897.

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